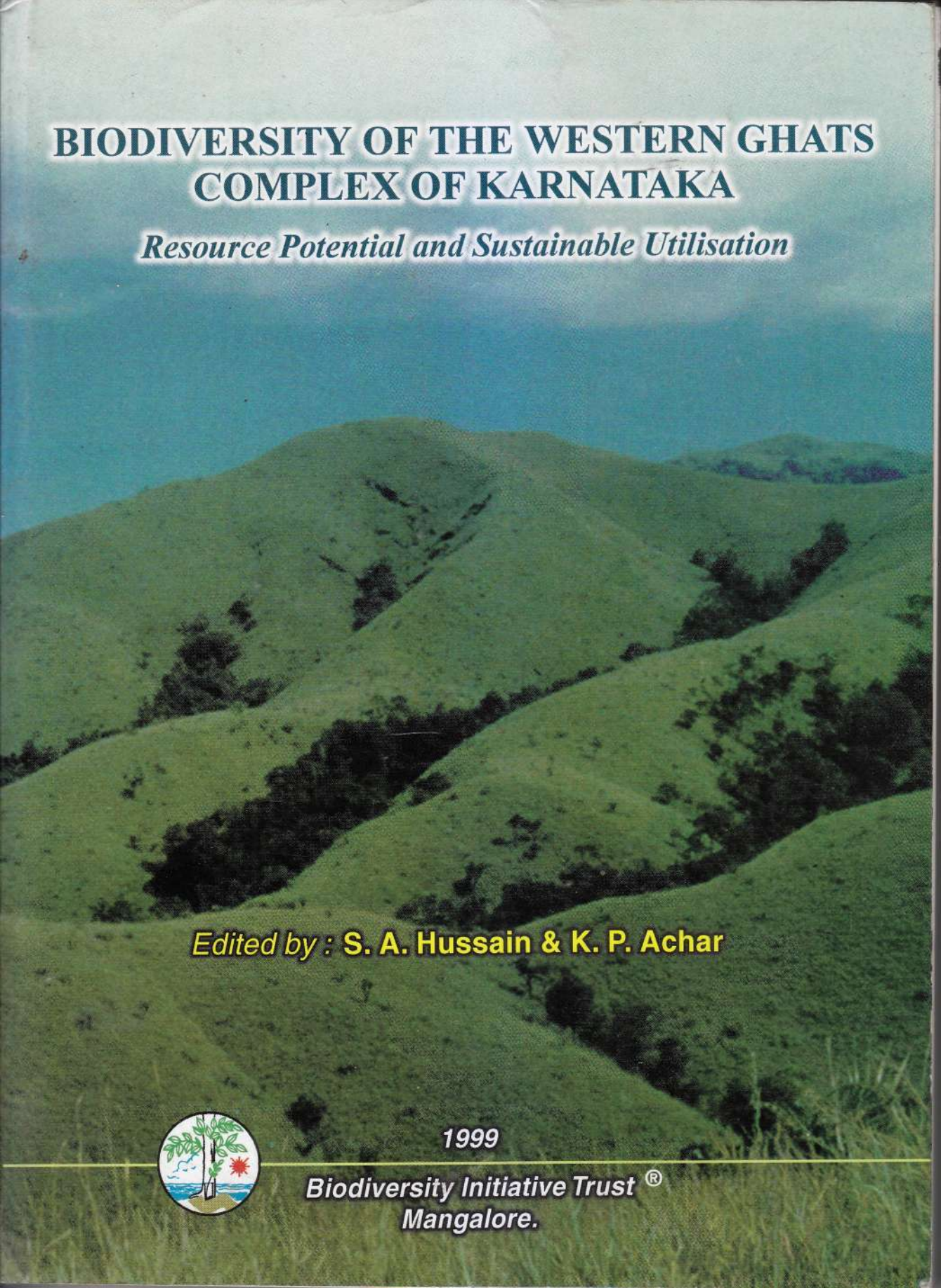
BIODIVERSITY OF THE WESTERN GHATS COMPLEX OF KARNATAKA

Resource Potential and Sustainable Utilisation



Edited by : **S. A. Hussain & K. P. Achar**

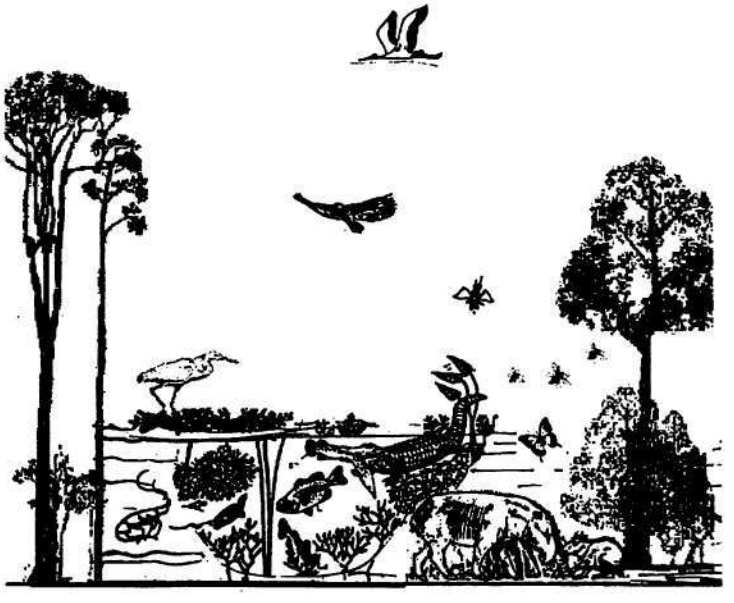
1999

Biodiversity Initiative Trust ®
Mangalore.

BIODIVERSITY OF THE WESTERN GHATS COMPLEX OF KARNATAKA

Resource Potential and Sustainable Utilisation

Edited by : **S. A. Hussain & K. P. Achar**



1999

Biodiversity Initiative Trust ®
Mangalore.

Published by : Biodiversity Initiative Trust ®
"Basera", Amar Alva Road,
Monkey Stand, Mangalore - 575 001,
Karnataka, India

Citation : Hussain S. A., & Achar K. P. Eds. 1999. *Biodiversity of the Western Ghats Complex of Karnataka: Resource Potential and Sustainable Utilisation.* Biodiversity Initiative Trust. Mangalore, pp 253

Cover photograph : Kudremukh National Park
Photo credit : H. S. Ananth

Printed by : Praveena Mudrana,
DTP and Offset Printers
Mahalaxmi Temple Lane
Karkala - 574 104.
Karnataka, India

Available from : Biodiversity Initiative Trust ®
"Basera", Amar Alva Road,
Monkey Stand, Mangalore - 575 001,
Karnataka, India.
Email: <*sahbird@vsnl.com*>

" WE WISH TO THANK THE OFFICE OF INTERNATIONAL AFFAIRS, U. S. FISH & WILDLIFE SERVICE FOR THEIR ASSISTANCE IN THE PRINTING AND DISTRIBUTION OF THESE PROCEEDINGS"

Western Ghats Biodiversity Conference '97.

4 - 5 October 1997

Venue

Sri Bhuvanendra College Conference Hall, Karkala - 574 104.

Organisers

Sri Bhuvanendra College, Karkala - 574 104.
Bhuvanendra Nature Club - India
Biodiversity initiative Trust ®, Mangalore - 575 001.

Sponsors

Ministry of Environment & Forests, Govt. of India. New Delhi.

University Grants Commission, New Delhi

Academy of General Education, Manipal

Kudremukh Wildlife Divison, Karkala

Kundapura Forest Divison, Kundapura

Sri Bhuvanendra College, Karkala

Pawan Jewellers, Karkala

Biodiversity Initiative Trust. Mangalore

Editorial Note

This is a preliminary attempt to collate some information of an area which is considered to be the one of the major "hot spots" of biodiversity regions of the world. The organisers of the Conference achieved some success in bringing together some of the players dealing with the resources in the area despite the remoteness of the venue, thanks to the cooperation of various agencies, including the staff and students of Sri Bhuvanendra College.

It is to be admiitted that a vast array of the biological components of the area have not been touched at all, which is mainly due to paucity of research done and information readily available. Some of the important components such as mammals, molluscs and angiosperms though very important, are not included. In agricultural and fisheries sectors too there is a general lack of information. On the whole this preliminary offering, if anything, helps in underscoring the urgent need to gain more knowledge of the vast unrecorded resources available in our rich ecosystem.

We hope that this maiden offering will help spur more action to not only institute vigorous inventory and field research by various colleges, Universities, NGO's Government agencies as well as private and agro-horticultural sectors but also create awareness among common people, entrepreneurs, bureaucrats, legislators and decision makers about the need to ensure sustainable utilisation and conservation of the biodiversity resources of our area.

The publication of this proceedings is maiden effort by a small NGO in a small town and by a small Printing Press. The editors express their appreciation of the efforts put in by all the small people in making this small attempt at chronicling huge natural resources of our area.

There was the inevitable delay in publishing the proceedings due to difficulties encountered in accessing the necessary funds. But now it is possible to do so from a grant from U. S. Fish & Wildlife Service. Our grateful thanks to a timely and kind help by Mr. David Ferguson of the United States Fish & Wildlife Service, Washington D. C., U. S. A.

S. A. Hussain

K. P. Achar

Preservation and Sustainable Use

The conservation of biodiversity or for that matter any natural resource can be defined as its maintenance at a certain optimal level such that it does not vanish on its own or owing to the ongoing human impacts such as maintenance, does not preclude human usage of these resources. Hence, the process of conservation can be thought to consist of two components: preservation and sustainable use. Preservation would imply that human's keep their hands off the resource and ensure that it suffers no damage owing to other human induced impacts like pollution. The act of preservation therefore imposes certain costs such as (a) sacrificing certain immediate benefits from likely usage of available resource; (b) investments needed for special protection; (c) likely losses in terms of extra, unnecessary conservation efforts in case some future technological advances that replace or minimize the current resource requirements.

Humans, guided mostly by their self interests, are usually not inclined to sacrifice short term benefits or make heavy investments, no matter how much the pundits insist on the ethical, cultural or religious values of biodiversity conservation. Even the long term gains rarely motivate people if they are too limited or intangible or it is not secured. Hence, if some immediate gains are likely to compensate for at least part of the preservation costs, human societies are seen to take up conservation measures. Given all these hypotheses grounded in countrywide empirical evidences in real life, the sustainable use seems to be a precondition to biodiversity protection. (Gokhale et al in press).

The Extinction Risk Estimates

It is necessary to place the concepts of the resource depletion and sustainable use in a wider - global as well as historical-context. Over millions of years, evolution gave rise to the enormous biodiversity that we see today, starting from a few molecules of life that probably developed in shallow coastal waters (Gadgil, 1997). This spatial and temporal expansion of life, however, has been far from gradual. There have been sudden bursts of speciation as well as mass extinctions, following periods of favourable and unfavourable environments respectively e. g. much talked of extinction of dinosaurs. The current rates of human caused extinction are over thousand times greater than the natural, background rates of extinction (Heywood, 1997). However, the scale of total extinctions faced by world today is probably not far greater than earlier mass extinctions. No doubt, the prospects of global climate change pose a potentially serious yet imprecisely estimated threat for the survival of the natural biodiversity. However, the direct threats due to the humans have not reached unprecedented proportions so far. We still have not completely run out of time to save much of world that remains.

TABLE OF CONTENTS

WELCOME ADDRESS AND INTRODUCTION TO CONFERENCE

S. A. Hussain
President, Biodiversity Initiative Trust., Mangalore

It gives me great pleasure to welcome everybody to this inaugural function.We were hoping that Shri. Veerappa Moily, former Chief Minister of Karnataka and the sitting M.L.A. from Karkala would be here to preside over the function. Though Shri. Moily made all arrangements to be here, unfortunately for us, due to some emergency that cropped up last night, he had to leave for Bangalore early this morning. This was so sudden that the organisers were truly in a very tight situation. We were very lucky to have a very distinguished person with us , Dr. J.C.Daniel, who very kindly agreed to preside over the function.

Among the other VIP's that were to adorn the dais as per the programme today, I see that Shri. B.H. Anil Kumar, Dy. Commissioner, Dakshin Kannada, is not with us, though he had agreed to attend, while Ms. G. Kalpana, Dy. Commissioner, Udupi district has indicated at the last minute that she is unable to attend. Now let me formally welcome our distinguished Guests on the dais and the audience.

First of all on behalf of the organisers I extend a very warm welcome to Dr. J.C.Daniel who will not only be presiding over the function but also will be delivering the Keynote Address. Dr. Daniel is a close associate of late Dr. Salim Ali, and has had a long innings at the Bombay Natural History Society (BNHS), as its Director. While his expertise encompasses all branches of Natural History , his speciality includes reptiles, amphibians, mammals and birds and has been a guide for MSc and PhD degrees in these subjects in the Bombay University. He has been the editor of the Journal of the Bombay Natural History Society over three decades besides writing books on reptiles, mammals and amphibians. His keynote address will definitely be the highlight of this conference.

Welcome to Shri R.K. Singh, D. C. F. (Wildlife), Director of Kudremukh National Park. It is our good fortune that his office is located in this town. We have taken the full advantage of this and have sought his support for this conference which he has whole heartedly given.

Welcome to Shrimati Madhu Sharma, Divisonal Forest Officer, Kundapura Forest Division. Our newly formed Udupi district has the distinction of being governed by three exceptional lady officers - the Dy. Commissioner, the Superintendent of Police and the Divisional Forest Officer. Shrimati Sharma has enthused some degree of dynamism in the forest service in the district.

Welcome to Shri M. K. Srinath, CEO of the Karnataka State chapter of the World Wide Fund for Nature- India (WWF-I). The WWF , as we all know, is an important NGO involved in conservation of nature as well as conducting nature camps and outdoor nature studies for school children.

Prof. S. R. Malli, Principal of Bhuvanendra College had to leave for Delhi to attend an important Seminar, but has made it sure that the function goes on well in his absence. He has asked his deputy, Prof. P. R. Bhat to guide organisers of the conference. I welcome Prof. Bhat .

Welcome to Dr. K.P. Achar, the man behind the scene in organising this conference. It was he who asked me when I returned from Malaysia to do something to conserve the rich heritage and biodiversity of the Western Ghats. He has a reputation of being a live wire in the College - infact we almost had a short circuit last night!

Organising a conference of this nature is not an easy task, particularly in an out of the way place like Karkala. But after working with Dr. Achar and his colleagues, I realised that the college has rich experience in successfully organising conferences of various kinds and has a very good track record. We had the usual scary moments about problems of fund raising but these were overcome with some manoeuvring at appropriate places.

Introduction to the Conference

The term "biodiversity" has become a catch word after the 1992 Rio Summit where the heads of the states from all over the world assembled to deliberate on the need to conserve and sustainably use the natural resources. The survival of world's human population depends on the biological resources. It is no longer a romantic notion of a few "nature lovers" and conservationists but the very basis for the survival of a all living creatures of the world.

The matter has suddenly become a global concern as the world finds itself sailing in the same boat and facing the collective responsibility of steering it properly or facing the prospect of sinking collectively.

Development of living standards, provision of food & shelter and enhancing economic status are the major occupation of industry, commerce, agriculture, trade and business sectors all over the world, not to speak of the underlining profit motive. While all these entities are essential for economic advancement they are also not admitted or is simply down-played. Over - exploitation and rapid depletion of natural resources; pollution of land, water and atmosphere; degradation of soil; denudation of forests and drainage of wetlands are the direct result of such activities.

While rapid advancement in industrial sector has ensured a better life and social conditions for global communities, it is becoming increasingly apparent that the quality of life and the health of the earth and its inhabitants is also greatly affected by these activities. In the recent years greater awareness has been created about the need to harmonise development with environment that we live in.

Brief statement of the Objectives of the Conference.

The Earth Summit in Rio as also at the Rio+5 meeting at New York this year, the Contracting parties to the Biodiversity Convention reiterated their commitment to conservation of the earth's biological diversity and the responsibilities of individual States in conserving and sustainable use of biological resources within their jurisdiction.

The main plank of the Convention is the emphasis placed on approaching biodiversity conservation from a development perspective. The Convention's approach also emphasises action within each sovereign country in identifying its biological capital, developing and implementing a national biodiversity strategy, conserving biodiversity in situ and ex situ, and using biological resources sustainably.

Need for consultation at regional level

The Western Ghats of Karnataka are perhaps the most productive and least overexploited region with large tracts of pristine forests, well wooded areas and unspoilt coastline in the peninsula. The region straddles the districts of Uttara Kannada, Dakshina Kannada, Shimoga, Chikmagalur, Hassan and Kodagu and perhaps has the largest combination of plantations, agrifloriculture, fishery and other economic produces.

Considering the fact that the six districts encompassing the Western Ghats and coastal areas of Karnataka posses rich biodiversity and that the existing and potential biological resources need to be reviewed and assessed as well as a possible future strategy may

be formulated for a sustained utilisation of the resources and at the same time ensure adequate measures for the conservation of unique biological resources of the region, a state-level Conference is being organised.

Aims and objectives of the Conference:

The Conference is being organised to address three main issues.

1. To understand the current trends in biodiversity research and its status as well as its impact on science and economy.

2. To bring together the knowledge and results of the past and ongoing research relating to biological - assessment and inventory being conducted by field researchers in the Western Ghats and its command area.

3. To review the status, impact and problems and prospects of the use of biodiversity resources on farm and commercial sectors of the region.

Expected Outputs

1. It is envisaged that the papers presented in the sessions will provide an opportunity for the students and faculty members of the universities, NGO' s and institutions of the region to not only understand and appreciate the richness and abundance of the biological diversity in the region but also enable them to interact with the experts in the field and benefit from their wisdom.

2. Participation by farm, plantation and other sectors will provide a common platform for the scientists, conservationsts governmental and the commercial sectors to try and understand one another's perceptions, points of view and concerns and at the same time promote useful dialogue for devising ways and means to utilise the biodiversity resources in a sustainable manner and thereby minimise the loss of biodiversity.

3. Published proceedings of the conference will provide an useful compendium on the biodiversity of the area as well as its current status and its sustainable utilisation in the future.

4. It is also envisaged that the conference will initiate regular future dialogues, interactions and consultations between the government agencies, NGO's, scientists, academicians, students and the corporate sector and stimulate them to cooperate in conservation and sustainable use of biodiversity in the region.

Target audience

The conference will target University staff and students, government officials, conservation NGO's, Research organisations, private and public farm, plantation, agri-horticulture and food processing sectors as well as print and other media of the region

Implementing the recommendations of the Conference.

It is planned to distribute the recommendations of the Conference to all University colleges and State and Central Research Institutes, Forest and Wildlife Department of the state, Government agencies, Planation sector as well as Environmental NGO's.

Biodioversity Intilative Trust will keep a constant liaison with all the state agencies and farm sector as well as government agencies on implementing the recommendatins. Wherever appropriate it will assist in follow up action.

Biodiversity Initiative Trust, with the help and support from funding agencies, will continue to organise future Conferences/ Seminars/ Symposia as well as conduct training programmes and orientation courses to relevant entities.

BIODIVERSITY CONSERVATION - CHALLENGES BEFORE US

J. C. Daniel
Hon. Secretary, Bombay Natural History Society,
Salim Ali Chowk, Mumbai - 400 023

The tropics girdling the earth upto 23°28' north and south of the Equator have the richest biodiversity among all the biogeographic regions of the world. The number of species that live in the tropical rainforests is still unknown though their abundance has been noted from the time of the nineteenth century naturalist-explorers. The richness of biodiversity decreases north and south of the Equator. The tropical rainforests which are largely equatorial show very little fluctuation in annual temperature regimes and thereby provide uniform living conditions. They tend to fluctuate as one proceeds north and south from the equator ending in the seasonal regimes seen in the temperate regions and their extreme manifestations in the arctic regions. The uniformity of environmental conditions prevailing in the rainforests leads to a proliferation of species but the number of individuals of each species is considerably less than what occurs among species which occur in regions with much more diversified environmental conditions. Uniformity of environmental circumstances assures less stress and lesser risks for survival. Therefore a species is able to survive in lesser numbers in its own niche in the monotony of uniformity. "Living fossils", that is species which have not changed over many millennia, are more likely to be found under such stable conditions. As environmental conditions fluctuate, stress increases, making a species face unpredictable environmental conditions. Under such situations an increase in the number of individuals of a species is of advantage to its survival. The fauna of the rainforests are examples of a low number of individuals of species but exemplarily a rich biodiversity, whereas, as we go away from the Equator towards the higher latitudes, variable environmental factors reduce biodiversity, but individual numbers of each species increase correspondingly.

The tropical regions of SE Asia have a variety of climatic regions, commencing with equatorial rainforests, evergreen forests, wet-deciduous forests, dry-decidous forests, dry thorn forests and glasslands depending on the rainfall regimes. Each region has its own

biodiversity with a dominance of species particularly suited to the habitat it occupies. The rainforests and evergreen forests of Western Ghats for instance have an abundance of canopy dwelling fauna, particularly primates. The Indian subcontinent with its climatic regimes ranging from evergreen rainforests to temperate and arctic conditions provides examples of all the tropical climatic regimes of SE Asia and varying richness of biodiversity.

As far as the status of biodiversity is concerned we still have a long way to go in assessment of biodiversity. Enumeration of biodiversity is not new in India for we have had several species surveys. However, in the past such surveys concentrated on particular groups such as the Mammal Survey of the Bombay Natural History Society which collected species of mammals from identified areas all over the Indian subcontinent, Burma (now Myanmar) and Sri Lanka between the years 1913 and 1923. Most of the information we have on the distribution of Indian mammals is based on this extensive survey. Similarly, the bird surveys of Dr. Salim Ali from selected areas of the subcontinent drew attention to the species richness and diversity of the subcontinent. He was particularly interested in the avian species richness of the Western Ghats as can be seen from his surveys in Travancore, presently Kerala and Mysore, the present day Karnataka. Presently the Botanical and Zoological surveys have collected considerable data by their studies on the flora and fauna of different states and biotic regions in the country. We, therefore, have information on some components of the biodiversity of selected areas which are of interest to scientists of particular disciplines but we do not have complete information on the total biodiversity of any specific region or ecosystem. While the angiosperms among the flora and vertebrates among the fauna are fairly well documented, life at a lower level is little known. Biodiversity cannot be properly assessed until we have information on the complete faunal and floral wealth of an area. How little is known of biodiversity even among vertebrate groups was made evident recently. I was involved in two exercises for prioritisation of the conservation status of two vertebrate groups namely reptiles and mammals. Among the 495 species of reptiles recorded within Indian limits of the subcontinent, 133 had to be marked as data deficient, that is slightly over 25% of the known Indian species. Similarly among the 367 mammals of India 129 or nearly 1/3rd of known mammals were data deficient. What this means is that we have no information on their ecology and their role in the ecosystem in which they occur.

If this is the situation in groups which recieve special attention from biologists and conservationists the situation among other groups often obscure but perhaps key elements in the maintenance of biodiversity can well be imagined.

It is in their richness of endemic fauna that the tropics excel. Endemism is an expression

of species richness and habitat specificity. Areas with high endemism are generally rich in biodiversity as they provide an environment for development not occurring elsewhere.

Among the three groups of Indian vertebrates which were recently assessed for prioritisation of conservation requirements, namely, the amphibians, reptiles and mammals, 24 amphibian species were endemic, of which 16 are restricted to the Western Ghats, 199 reptile species were endemic, the majority being from the Western Ghats. Approximately 48 species of mammals are also endemic to India.

The Western Ghats are particularly productive of endemic forms of mammals. As in other high rainfall areas with high density canopy habitats, the evergreen forests of the Western Ghats show a predominance in its biodiversity of canopy dwelling species and endemism generally in its forms. Among the primates for example, two species are endemic to this area, the folivorous Nilgiri Langur *Trachypithecus johni* (Fischer) and the frugivorous, as well as omnivorous, Liontailed Macaque *Macaca silenus* (Linnaeus).

An endemic species of the evergreen and semi-evergreen forests of the Western Ghats is the Brown Palm Civet *Paradoxurus jerdoni* Blandford. Its habits are only being studied now.

Other endemic forms are the large sized Stripenecked Mongoose *Herpests vitticollis* Bennet and the Brown Mangoose *Herpests fuscus* Waterhouse, both limited in their distribution to the high rainfall forests of the Western Ghats.

A single species of marten occurs in the tropical forests of the subcontinent; the Yellowthroated Marten *Martes gwatkinsi* Horsfield of the high rainfall hill forests above 1000m of the Western Ghats in the states of Kerala, Tamil Nadu and Karnataka.

Among bats the most noteworthy species of the Western Ghats and perhaps of the world is the Wroughton's Freetailed Bat *Otomops wroughtoni* (Thomas). The only known population of this species consists of a single colony in a cave in the high rainfall forests of North Kanara in Karnataka.

Among endemic squirrels the Small Travancore Flying Squirrel *Petinomys fuscocapillus* Jerdon is restricted to the evergreen forests of the southern ranges of the Western Ghats as also the Pencil-tailed Dormouse *Platacanthomys lasiurus* Blyth.

There is a remarkable similarity in the bird fauna biodiversity of the wet evergreen forests of the Western Ghats and of North Eastern India. The number of species is however,

higher in the evergreen forests of eastern India. Some of the species which are common to both regions are the Fairy Blue Bird *Irena puella* (Latham), Imperial Pigeons *Ducula* sp., Great Indian Hornbill *Buceros bicornis* (Linnaeus), Bearded Bee-eater, etc. Many of these are habitat specific and will disappear as the habitat is degraded and lost.

The status of the avifauna is often a good indicator of the status of the biotic environment.

The reptilian fauna of the Western Ghats is largely dominated by Indochinese elements, relicts of a period of India's geologic history when the Peninsula had a much higher rainfall than what it experiences today and the vegetation and ecological factors were identical to what obtains now in the Indochinese faunal section of the country, the eastern Himalayas and Assam and other states of eastern India. A relict of this fauna now occurs in the high rainfall areas in the Western Ghats principally below 15° N latitude. Several genera such as *Draco* (Flying Lizards), *Chrysopelia* (Golden Tree Snake), *Geoemyda* (forest terrapin), *Dasia*, have the same or closely related species occuring in the Western Ghats and North Eastern India with an intervening gap in distribution in the Peninsula where conditions have now become unsuitable for these high rainfall habitat species. At this point it may be appropriate to consider the status of biodiversity in other parts of the country. A recently published book "Changing Perspective of Biodiversity Status in the Himalaya" has a chapter on current status of Biodiversity in the Himalayas and discusses the status of flora, wetlands, crops, livestock and includes a case study on Bamboo. About 40% of the Himalayan flora is endemic, and the flora generally is rich. The Himalaya is a centre of floral diversity but biotic interference has taken its toll and several species have either disappeared or have become dangerously threatened. The case study on the bamboo, for instance, establishes that the high altitude alpine bamboos, an important source of food for wildlife and equally important for erosion prevention of a fragile enironment, are under heavy grazing pressure. The Himalayan fauna which has both palaearctic and a rich Indomalayan component, with many species adapted for life at high altitudes, presents a gloomy picture. About 160 species of crop plants are reported to have originated in the Himalayas and efforts are being made to save the germplasm by Indian institutions but the need seems to be *in situ* conservation which requires "Conservation farms" for long-term conservation and protection of germplasm in the field. Himalayan wetlands, especially those of the arid highlands of Ladakh and the wetlands of the Kashmir valley, are of high biodiversity interest and call for attention.

A question often asked is: Can biodiversity be used on a sustainable basis? Biodiversity by itself does not lend itself to sustainable use. It is a concept. But the components can be used or harvested. However this requires an indepth study of the role of the species

in the ecosystem and what part of the total population of the component species can be removed without affecting either the species or its role in the ecosystem. This type of exploitation or possible exploitation of component elements of an ecosystem rich in biodiversity often, or more or less exclusively, relates to plants considered to have medicinal properties and therefore of economical value. Exploitation within a protected area can only lead to the destruction of the areas' biodiversity, as so far, no method of reasonable exploitation has been devised and such use inevitably leads to over exploitation as human greed cannot be controlled. The only possible method is cultivation outside the protected biodiversity conservation area. However considering the disastrous effect that mono-culture cultivation of coffee, tea and rubber has had on the biodiversity of the Western Ghats - introduction of another monoculture would only mean more areas of biodiversity requiring conservation will be lost to commercial exploitation. It is my belief that exploitation of existing *in situ* resources even at the tribal forest village level will only lead to the removal of a particular constituent of the ecosystem's biodiversity.

Apart form the adverse effect of mono-cultures on Western Ghats biodiversity, the devastating effect of introduced exotics has to be noted, particularly of plant species *Lantana, Eupatorium* and *Parthenium*. Introduced largely inadvertently, they have been the main cause of drastically reducing biodiversity values of many areas of high biodiversity in the Western Ghats. They have become such an integral part of the system that some species are presently considered as part of the system and their removal does not receive the attention that it deserves. In this context the surreptious cultivation of the weed *Cannabis* in protected areas has also to be noted as another factor affecting the biodiversity of the Western Ghats.

The challenges facing biodiversity conservation in India are manifold but the crux of India's Biodiversity Conservation problems is its human population. Demands on natural resources for human needs and the needs of domestic livestock are so great that very little is left for any other forms of life. These effects are most heavily felt by all life forms.

A brief review of some basic environmental parameters and stress they presently bear will help introduce the problem. India, although having hardly one-fortieth of the world's land surface, supports more than one-half of the world's water buffalo and more than one-seventh of its cattle and goats. The effect of the constantly increasing pressure of these domestics on the land (particularly grasslands and forests) has been disastrous. In India, land urgently in need of rehabilitation because of wind and water erosion, salinity and alkalinity, now exceeds an area of 100x106 ha The Chambal Valley, with 4x106 ha ruined by erosion ravines, is a classic example demonstrating what can happen elsewhere. Another continuing

pressure on land resources is for urbanization. The urban Indian population is the fourth largest in the world, and it will continue to grow while agriculture on impoverished land, fragmented by inheritance distributions among members of a family, fails to support the increasing rural population. At the same time, more agricultural land is taken up to meet the demands of urbanization. Approximately 1.5x106 ha of arable land have been lost in this manner since 1950. These losses are borne in the final assessment by the forest and grassland habitats, the repository of the coutry's biodiversity.

The second most important factor is water conservation. In historic times, rainfall was stored in ponds and tanks and this water was apparently sufficient to meet the requirements of the human population. These storage reservoirs neither have been maintained nor have increased in number to conserve water while meeting the needs of an expanding population. India still uses only one-tenth of the rainfall that it receives. Floods wreak havoc each year, but India still lacks an effective policy of flood control and water conservation. Groundwater reserves, which were once 10 times as great as the annual rainfall, have been so over used that in many areas the water table has fallen far below economically retrievable levels. Aridity is now threatening many areas which were once fertile.

The third major need is energy. Firewood remains the main source of energy for cooking in India and particularly in villages where it may be the only source. Urban India alone uses 20x106 tons of firewood, worth>5000 million rupees (>U.S. $350 million), more than what was spent on afforestation between the years 1950 and 1980. The effect of this endless demand on resources is evident considering the area under forest cover. Satellite data indicate that India is losing 1.3x106 ha of forests per year; more than 8 times the figure given by the forest departments of the various states (Agarwal and Narain, 1985).

If there is to be a future for biodiversity in India, studies on the ecology of the components should be given priority. It is necessary to identify the major constraints. Problems requiring immediate attention in the conservation of biodiversity in India can be considered in order of priority.

The most crucial problem is habitat loss. Usually there is a gradual decline in habitat quality that is not evident unless all parameters of the system are examined. The endangered species are likely to be the best indicators of the loss of such habitats.

Long-term studies on the ecology of such endangered habitats, presently found only in various sanctuaries and protected areas, require urgent consideration. Unless these areas are sustained and rehabilitated where degradation has set in, conservation of biodiversity in India is a lost cause.

Constant and continued ecological monitoring is essential for biodiversity hotspots if they are to survive. Endangered species are often the indicator species for the status of an endangered habitat.

Can there be sustainable development considering the enormous population pressure on existing resources and the stress on indigenous cultures from the inroads towards uniformity in living standards introduced by better communications towards a one world standard? Some economists believe so but their arguments are not very convincing. Take for instance the jhuming cycle in north-east India which has come down through population pressure to less than 5 years, leading in some cases to annual cropping. Biodiversity is hardly likely to survive under such conditions. The sacred groves, repositories of biodiversity, are either being degraded or disappearing. In the Himalayas degraded ecosystems make up 20% of the total geographical area. Water management remains a key to ecosystem rehabilitation. On the whole we are facing a losing battle against the disappearance of human life styles and the regional biodiversity which supported them.

There is an urgency for protection which continues to be smothered in apathy and inaction. The manner in which the biodiversity wealth of the country can be monitored and managed has to be discussed, to prevent the nations natural wealth being sold down the river of commercial greed. Also we must examine how best to protect Indian Biodiversity, particularly of the medicinal plants, from the multinational pirates on the prowl. The answer seems to be, in these days of GATT and Patent laws, to cover the nation's biodiversity wealth with a legislative blanket of laws enforcing national sovereignty. Action has to be taken before it is too late.

BIODIVERSITY CONVENTION - SOME FACTS

S. A. Hussain
Biodiversity Initiative Trust., Mangalore

It is estimated that over 2,100 million species occur on earth of which over 1.5 million only been identified by the scientists. All our food items originated from the wild species which have been domesticated. Humankind depends for its staple food on just four species of plants: rice, maize, potato and wheat. The dreaded childhood disease Leukaemia is today treated by drugs derived from a species of periwinkle from Madagascar. A tremendous genetic and biochemical diversity exists among inverteberates in soil and the micro-organisms near hydrothermal vents on the ocean floor may be very valuable to industry because of their heat-stable enzymes.

It is an accepted fact that the Tropical Rainforests, which comprise of 7% of the earth's surface, are richest in biodiversity. By virtue of this rich diversity in both animal and plant species, rainforests have contributed a great deal of items for the survival of humankind which include basic food items, clothing, shelter, fuel, industrial raw material and medicine.

In recent years it is becoming increasingly apparent that Earth's biodiversity is being threatened faster than, say over 65 million years ago when Dinosaurs became extinct. It is predicted that at current rates of extinction the Earth will lose about 20% of all its living species by the year 2020 - a loss both directly and indirectly attributed to human activities that result in habitat fragmentation and its eventual loss, overexplolitation of living resources, pollution and other factors.

One of the most significant outcome of the 1992 Earth Summit at Rio de Janerio was the coming into effect of the Convention of Biological Diversity. Over 150 Heads of Governments of the world, by signing the Convention Treaty, set in motion a process that enables the countries to a legally binding instrument to conserve their respective biological diversity and at the same time utilise the resources in a sustainable manner. It is a significant

fact that it took shortest time possible for the Treaty to become effective as international law on 29 December 1993. It is indeed the first international agreement of its kind, given its comprehensive scope and totally novel approach.

Hitherto the emphasis had been on conserving and protecting ecosystems as a "common heritage" and as such not seen as an essential element of "development" process. As a matter of fact, the term "environmental conservation" was being looked down as something the world community cannot afford to have in the face of ever increasing demand for resources for developmental process. Environmentalists were regarded rather sceptically as anti - development. However, the Biodiversity Convention Treaty has changed all that and the community of nations have come to regard conservation of biodiversity as a multi - sectoral issue of sustainable development and as such a "common concern" rather than "common heritage".

The Convention has three broad objectives : The Conservation of Biological Diversity, the Sustainable use of its Components, and the Equitable Sharing of the Benefits Arising from the utilisation of genetic resources. Provisions stipulating specific commitments towards achieving these goals are covered in 42 legally binding Articles spanning a broad range of areas which include: Measures for Conservation and Sustainable use of Biodiversity, Financing Arrangements, Access to Genetic Resources, Transfer of Technologies Derived from these Resources, and Biosafety related to Genetically Modified Organisms.

Biodiversity can be explained as - a variety or variability of living organisms on earth such as species of plants, animals and micro-organisms and the total ecosystem they compose. Biodiversity affects us in may ways - for advances in agriculture, fisheries, forestry and biotechnologies. They support a range of essentials such as clean water, medicines, flood control and maintaining an ecological balance in nature.

The Biodiversity Convention is a spontaneous global response to a most urgent and common crisis facing the human kind - the loss of Biological Diversity. Unfortunately, most people, particularly those engrossed with "development" of national and global economies, do not seem to understand or appreciate these sentiments. For them, rightly or wrongly, "development" of living standards, provision of food & shelter and struggle for enhancing economic status are paramount - even to the extent of ignoring the conservation of the very resources they are dependent upon.

Cost of conservation is high. Preserving pristine areas of biodiverse marine, forest

and other ecosystems means not only foregoing commercial returns from their exploitation but also incurring additional and substantial long - term cost of protecting and maintaining them. Conservation of biodiversity need to be balanced by a right to utilise the resources sustainably. However, all these efforts need financial resources and appropriate mechanism to allocate these resources. Agenda 21 adopted at the Earth Summit in 1992 estimated that between 1993 and the year 2000 about US $ 3.5 billion will be needed annually to fund the activities for Biodiversity Convention. The developing countries do not have this kind of money to sustain the activities envisaged in the Convention. However the Treaty stipulates national and international responsibilities for financing upon the developed countries to provide additional financial resources to developing countries absolutely free of any conditionalities.

It is a well known fact that both governmenrts and NGO outfits of all colour and hue look down upon the Corporate sector as the exploiters and polluters of natural resource. While the natural tendency of business sector is to make profit from every possible angle, it will be more advantageous to have them on the negotiating table if only to make them responsible for sustainable utilisation of the resources but also to pay for its conservation. Only then there will be an equitable distribution of responsibility for conservation and utilisation of biodiversity resources.

The text of the convention is a long-drawn scientific- cum-legal treaty and it will be impossible to give it here in full detail. However some important points of the convention are listed out with brief descriptions herewith:

Convention on Biological Diversity

Biodiversity : A variety or variability of living organisms on earth such as species of plants, animals and micro-organisms and the total ecosystem they compose

Convention: An instrument of legally binding agreement between the World's States to sustainably use and conserve earth's biological resources

Main Objectives

1. Conservation of Biological Diversity

2. Sustainable use of its components

3. Equitable sharing of the benefits arising from the utilisation of genetic resources.

Legally Binding Articles: Most important being -

A. Measures for conservation and sustainable use of biodiversity

Contracting Parties will:

- Develop National Strategies, Plans & Programmes
- Integrate Conservation & Sustainable use into Sectoral plans
- Indentify components of biological diversity for Conservation or sustainable use
- Monitor the status of the components for *in situ* and *ex situ* treatment as appropriate
- Institute Research and Training as well as promote public awareness

B. Access to genetic resources

Contracting Parties will:

Take Legislative, Administrative and Policy measures within their domain to create conditions to facilitate sharing of genetic resources on mutually agreeable terms.

C. Access to and Transfer of Technology

Contracting Parties will:

Ensure adequate measures individually & collectively for access and transfer of technology, giving due mutual recognition of Patents and Intellectual Property Rights

D. Bio-safety Related to Genetically Modified Organisms.

Contracting Parties will:

Ensure protocols for transferring, handling and use of genetically modified organisms resultilng form bio - technology in respect of any adverse effect in sustainable use and/ or conservation.

E. Financial mechanisms

Contracting Parties will :

Devise agreeable modalities for financing arrangements between the Developed and Developing countries on meeting the incremental costs for implementing the measures which fulfil the obligations under the Convention.

Evolving A Strategy For Conservation And Utilisation Of Biodiversity

Ghate Utkarsh [1, 2]

1. Centre for Participatory Management of Biodiversity, c/o FRLHT, 50, MSH Layout, 2nd Stage, 3rd Main, Anandnagar, Bangalore, 560 024.

2. Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.

Abstract

The global concern about biodiversity is growing as it is the basic resource material for the expanding science of biotechnology and its tremendous economic potential. However, the industrial and social concerns have shifted the focus of conservation from rigid, long term protection to sustainable utilisation and equitable sharing of benefits arising out of it. At a geographical level the conservation focus has to shift from few large pockets of pristine forests, grasslands and wetlands to overall landscape that also include a range of human impacted and artificial ecosystems. The responsibility of an adaptive broad based landscape management is now increasingly vested with the local village councils through the Panchayati Raj Act. Educational institutions can play a vital role in monitoring biodiversity and provide inputs for its decentralized planning. This paper demonstrates these concepts to be realistic through the concrete example of a network of 20 colleges in the Western Ghats and another 10 in Tamil Nadu. It also describes the likelylacunae in such effort and plans afoot to overcome these. It further indicates the necessary changes to be incorporated in the conservation policy and in particular, the existing patent and wildlife laws as well as proposed biodiversity and plant variety protection acts. Besides, monitoring surrrounding biodiversity should become a part of regular biology education. Finally, the paper elaborates how these initiatives fit well into the international framework of CBD and GATT.

Expanding Horizons

Conservation of biological diversity i. e., biodiversity, has now become a major global concern, both because of its recent human induced rapid depletion and enormous future socio-economic potentials. The newly acquired capabilities such as transferring genes across species or higher taxonomic levels, has opened up wide ranging possibilities of applications

based on biodiversity in the fields of food and medicine. Biotechnology based industries, it is estimated, might account for 40% of the global economy during the 21st century (Gadgil 1996a). With an eye on these likely benefits and concerned with ongoing erosion of this vital resources; over 150 countries in the globe have signed an International Convention on Biological Diversity (CBD). The convention has three main objectives: conservation of biodiversity, sustainable use of its components and equitable sharing of benefits arising out of its commercial applications amongst nations and human communities.

According to the convention as also other literature sources (Heywood et al 1996) biological diversity can be defined at various hierarchical levels such as: 'genes' (e. g. races and varieties of domestic plants and animals); 'species' (e. g. various species of birds or trees) and 'ecosystems' (e.g. various assemblages of species such as those sheltered in forests, wetlands, grasslands, coasts, fields, orchards etc.).

Conserving on Ground

Much of the research in biotechnology oriented towards production or development, is focused at the genetic level; whereas the science of conservation biology is mainly concerned with species and ecosystems. No doubt, the technology for *ex-situ* conservation (e. g. programme involving seed preservation through deep refrigeration or animal breeding in zoos, has made considerable advance of late. However, the genetic variability amongest this small pool of individuals remains very limited as compared to the wide variation within the natural populations. Given the restricted gene pool, the species becomes prone to heavy losses or even extinction due to any disease or physioclimatic stress. Further, as the process of natural evolution comes to a halt, there is little further intrinsic diversification in the genetic material under cryo-preservation. Above all, *ex-situ* conservation is a very costly affair and requires advanced technology. Both the resources are scarcely manageable for much of the developing and underdeveloped tropical countries, where much of the global biodiversity is concentrated. Hence, conserving the biodiversity in natural surroundings, off the laboratory, is the need of the hour (Soule 1986).

This is not to say that we should stop *ex-situ* conservation programmes. However, much of the manpower, funds and attention needs to be invested in maintaining and enhancing existing natural populations of species and the ecosystems they inhabit. This would allow for continuous natural evolution of genes, species and communities. This *in-situ* conservation approach could be aided by *ex-situ* conservation programmes, as a fall back option in the case of local or global extinction of a few important species, in the wild despite all the efforts.

Preservation and Sustainable Use

The conservation of biodiversity or for that matter any natural resource can be defined as its maintenance at a certain optimal level such that it does not vanish on its own or owing to the ongoing human impacts such as maintenance, does not preclude human usage of these resources. Hence, the process of conservation can be thought to consist of two components: preservation and sustainable use. Preservation would imply that human's keep their hands off the resource and ensure that it suffers no damage owing to other human induced impacts like pollution. The act of preservation therefore imposes certain costs such as (a) sacrificing certain immediate benefits from likely usage of available resource; (b) investments needed for special protection; (c) likely losses in terms of extra, unnecessary conservation efforts in case some future technological advances that replace or minimize the current resource requirements.

Humans, guided mostly by their self interests, are usually not inclined to sacrifice short term benefits or make heavy investments, no matter how much the pundits insist on the ethical, cultural or religious values of biodiversity conservation. Even the long term gains rarely motivate people if they are too limited or intangible or it is not secured. Hence, if some immediate gains are likely to compensate for at least part of the preservation costs, human societies are seen to take up conservation measures. Given all these hypotheses grounded in countrywide empirical evidences in real life, the sustainable use seems to be a precondition to biodiversity protection. (Gokhale et al in press).

The Extinction Risk Estimates

It is necessary to place the concepts of the resource depletion and sustainable use in a wider - global as well as historical-context. Over millions of years, evolution gave rise to the enormous biodiversity that we see today, starting from a few molecules of life that probably developed in shallow coastal waters (Gadgil, 1997). This spatial and temporal expansion of life, however, has been far from gradual. There have been sudden bursts of speciation as well as mass extinctions, following periods of favourable and unfavourable environments respectively e. g. much talked of extinction of dinosaurs. The current rates of human caused extinction are over thousand times greater than the natural, background rates of extinction (Heywood, 1997). However, the scale of total extinctions faced by world today is probably not far greater than earlier mass extinctions. No doubt, the prospects of global climate change pose a potentially serious yet imprecisely estimated threat for the survival of the natural biodiversity. However, the direct threats due to the humans have not reached unprecedented proportions so far. We still have not completely run out of time to save much of world that remains.

In putting the extinction threat into proper perspective, it is necessary to distance ourselves from some of the popular overestimates of sequential extinctions of much of the biodiversity. These are based on the premise that the ecological food webs being complex and intricately linked, extinction of one organism would eventually lead to that of many others dependent on it and this chain reaction would in turn bring about sevre depletion in the overall diversity. This is partly true as in the case of loss of keystone species that might critically effect survival of many dependent species (Heywood, 1997). However, there are few concrete evidences of ecosystem collapse or unprecedented sequential losses (Colinvaux 1995). The examples of loss of Calvaria tree which for its regeneration, required its seeds to be passed through the intestinal tract of the extinct dodo birds for breaking of the seed coat by the 'gastric juices', are only limited in numbers. On the contrary there are also examples of ecosystem restoration or replacement of the lost, dominant species by other less competent ones (Heywood, 1997). With this realisation, the doomsday predictions for the biodiversity and eventually the human race are no longer believed by ever growing number of people.

We should, therefore, focus on the potential utility of biodiversity, rather than the threats associated with its extinction, to motivate people. Admittedly, the utilitarian approach is being criticized as short sighted and narrow, as it might not ensure conservation when humans have access to better resources than the current natural biodiversity. However, we propose that use values attached to biodiversity need not be at the cost of non - use values like culture, religion and ethics. An appropriate locality and time specific - combination of various use and non - use should be promoted for greater efficacy. The approach to biodiversity conservation also needs to be diverse and not monotonous, with utility as its major component (Gokhale et al, in press).

Adaptive Management

Human populations have variously transformed the surrounding environment, as hunter-gathrers, as agriculturalists and as industrial civilisations. They have domesticated wild plants and animals, and through selection and breeding, diversified them immensely, thereby increasing their productivity, besides numbers (Heywood, 1997). While this has certainly added a great deal of deversity at the genetic level, human impacts over species or ecosystem level have been on the whole negative, although not simple enough to understand. While the creation of artificial reservoirs all over the country, providing opportunity for many waterfowl species can be considered a positive impact, shooting down of water birds is a significant negative impact. On the whole, humans have converted forests into scrub, grasslands or agricultural fields, dammed the rivers, created tanks or wells and during this processes, diversified the

landscape considerably. However, the area under natural ecosystems and populations of many wild species have substantially gone down, both due to these habitat transformations and over-harvesting (Pramod et al, 1997a).

As human societies went on depleting surroundings natural resources, they were also compelled to initiate conservation measures (Gokhale et al, in press). Although these strategies for sustainable use change vastly over space and time, they can be broadly categorized under the sacred elements like forest groves or temple ponds, predominantly seen as measures adopted by the hunter-gatherers, mostly tribals. The agricultural societies, through their kings established larger and less frequently occurring hunting preserves. The emerging industrial society has attempted to cordon off even larger areas in the form of wildlife sanctuaries and national parks.

However, humans have been changing their management not only over space but also time. Thus, when preservation measures enforced over large areas tend to restore the resource populations, people are tempted to re-harvest it, even unsustainably. Even socieities that were engaged in conservation over generations through self motivation are seen today sacrificing their resources for the monetary gains and related livelihood options (Gokhale et al, in press). Any conservation policy that is rigid and stationary, is bound to fail in the light of these observations. Hence the need to adopt management regimes that would allow adjustments in practices of resource use that are sensitive to local situation at a given time, and permit a judicious mix of preservation and usage (Gadgil and Rao, 1995).

Broadening Conservation Spectrum

The ever growing human desire for natural resources, has been actively moulding the current conservation policies too. The concept of biodiversity at species level is no more synonymous with just tiger, elephant and such glorious creatures. The diversity of cultivated plants, domesticated animals and their wild relatives is also attracting attention, given the economic potential of their use in hybridization and improvement programmes. At the habitat level, these species are found not in the pristine forests or grasslands or wetlands, but in the human impacted or artificially created ecosystems like the fields and habitations (Gadgil, 1996a, b).

At the geographical level also the conservation focus is now gradually shifting from a few islands of 'protected areas' to overall landscapes. For, neither the handful of urban environmentalists nor the government are able to stop industries from encroaching these islands for any longer. In some instances, the government seems to concede to the industrial

pressure and de-notify the sanctuaries in full or part as in the case of the Dandeli Wild Life Sanctuary in Uttara Kannada district. Local people could have fought against this industrial onslaught as in the case pf Congentrix Power Project in the agricultural settings of the Dakshina Kannada district. But today hardly any local community is motivated to protect a national park or sanctuary, as they are harassed and agitated by the anti people conservation policies (Bhatta and Bhat, 1997).

While the urban elites get away with the payment of the nominal tourism charges, that too for a few people and only occasionally, the rural peasants and tribals have to bear the cost of nature conservation by sacrificing their crops to wild boar or deer, and cattle or even human life to tiger or panther. No wonder, the prevailing conservation policies enforcing preservation of a few hotspots of diversity against the goodwill of local people are gradually giving way to fresh approaches of motivating people to conserve landscapes all - over.

Shifting focus from a few protected areas to a distributed network of village level live repositories is both essential and feasible. It is essential, given the lessons learnt from the growing science of Conservation Biology. The debate over whether it is advisable to invest into a few large, more contiguous areas or many smaller areas (single large or several small - SLOSS) is far from resolved (Soule 1986). Contrary to the popular notion, recent study on shola (i. e. montane, stunted evergreen) forests of the Western Ghats revealed that the smaller, fragmented shola patches harboured greater plant species diversity than the larger, intact pockets (Ganeshaiah et al, 1997).

Even as scientists are doubting whether the few large areas offer better conservation prospects, management of such large areas these days seem to be untenable on social grounds also. On the other hand, in tropical countries like India, there is a strong, thriving social tradition of small nature reserves distributed all over the landscapes. These community or privately owned conservation sites or practices like the maintenance of the sacred groves, ponds, regulated village woodlots, fish breeding pools along riverbeds are fast eroding due to the market pressure, processes of social disintegration and unsympathetic policies. However, success of new initiatives like joint forest management schemes of the government or several voluntary efforts raise hopes of rejuvenating traditional conservation practices and underline the need to strengthen them (Gokhale et al, in press).

Role of Educational Institutions

The responsibility of nature management and inventories is currently assigned to the centralized governmental agencies like the Forest or Fisheries Departments and Botanical

Zoological Surveys of India. Thus, we have Forest Department working plans for large areas like divisions (few 100 sq.km) over large time intervals (20 years) or checklists (one time, not periodic) of plants and animals from a taluka or district (few 1000 sq. km). These contribute a little to the small-scale (say a village, few tens of sq. km) and short interval monitoring (annual or biannual).

The responsibility and authority over such fine - tuned monitoring and planning is today being assigned to the panchayats ie. village councils by the Panchayat Raj Act and the related 73rd amendment to the Indian Constitution (Anon, 1997). However, given the prevalent low levels of awareness and resource allocations at the grassroots, the panchayats are largely ignorant, inefficient and inequitable in discharging their duties. To fulfill their obligations and to pursue sustainable as well as equitable development, the countrywide network of educational institutions like schools and colleges can play a vital role. For, they can document local resources, provide useful suggestions for development planning and enhance local awareness about rights, duties and opportunities.

NGOs are engaged in this work in many parts of the country, but their numbers and resources would by definition, remain limited. Hence, the only countrywide organisations dealing with information, a fundamental prerequisite of planning, is in the form of educational institutes. These institutions occur over all parts of India, in the rural and tribal areas, except some remote places. Besides, monitoring, biodiversity can become an interesting, useful and relevant part of their biology education (Gadgil, 1996b).

Western Ghats College Network

The Centre for Ecological Sciences (CES) at the Indian Institute of Science (IISc) began to experiment with these ideas for the purpose of biodiversity in 1994 when 18 colleges and 2 NGOs in the Western Ghats joined to form the Western Ghats Biodiversity Network (Gadgil, 1996b). Over the next three years nearly 30 teachers mainly from the Botany and zoology but a few even from the Statistics or Economics Departments; and their nearly 300 students enthusiastically participated in the research programme. Each college team consisted of a teacher or two and six to ten students. Some of the older students were replaced by fresh candidates during the project period. Each teacher spent about forty to sixty man-days per year while each student nearly a third of that. They also actively involved a couple of local knowledgeable villagers during the field work and sought their guidance.

Landscape Mapping and Remote Sensing

With a collective input of 120 to 200 days per year the study teams came out with

spectacular research outputs over next three years. Each team had chosen a neighbouring Western Ghats foothills village landscape as their study area, measuring about 25 sq km Using the standard habitat classification scheme developed by the IISc, the teams identified between 6 to 12 different habitat types from these landscapes. They then went on foot throughout the study area and mapped the distribution of major patches of each of these habitat types. Using these ground maps as an input for interpreting satellite imagery they digitally classified entire village landscape with the help of IISc and Regional Remote Sensing Service Centre (RRSSC) at Bangalore. They revisited the area on foot to check and modify the classified site as well as estimate and enhance its accuracy. We now have available with us information on patch characteristics of some 20 habitat types from 12 localities (Nagendra and Gadgil 1997).

Biological Sampling

The biological investigations from all localities yielded a sample consisting of 1,50,000 individuals belonging to some 1500 species of flowering plants, enumerated from 3000 quadrats distributed along 250 transects. In each locality, between 5 to 15 thousand individuals belonging to 200 to 600 species were enumerated. These data are currently being analysed to estimate abundance and density of species and populations in various habitat types and how these are influenced by the climatic parameters. We are also investigating patterns of species diversity, rarity, nichewidth and conservation values across habitat types and localities and their environmental correlates. Similar analyses are also in progress for over 10,000 birds belonging to about 212 species enumerated over 130 transects covering different vegetation types fom 18 localities (Pramod et al 1997a, b). Apart from such major, well known groups, we also have data on distribution of less common, more cryptic or taxonomically difficult groups like the caecilians i. e. legless amphibians (Bhatta, 1997; this volume), aquatic insects, freshwater mollusca, fishes etc.

People's Knowledge and Perceptions

The biological sampling is complemented by evolving an understanding of the local human influences on biodiversity and how these could be oriented and strengthened towards conservation purposes. For this purpose, the study teams undertook a participatory process of recording knowledge, uses and conservation perceptions of various social sectors in the village. The resultant document is termed as People's Biodiversity Register (Gadgil et al, 1996). It serves as an important decision making tool for not only the conservation and sustainable utilisation but also the equitable distribution of its benefits and nurturing traditional ecological knowledge. Techniques such as field visits with knowledgeable people, mapping,

group discussions, village meetings and individual interviews are employed for collecting and validating such information.

One section of the Biodiversity Registers record the changes occurring in the landscape over the last few decades, their impact on species populations and local people, the socio-economic forces driving these changes and the feasible options that the local people suggest, to curtail some of the negative impacts as well as to induce positive changes. Various social sectors may differ in their knowledge perceptions and priorities. This diversity of social opinion is also recorded as much as the prevailing consensus on many issues. The choices that people make for conservation are primarily classified into three categories - the biological (species or habitat patches) that they wish to protect, utilise or regulate; the management options (regulated extraction strengthening cooperative marketing or setting up of cottage industry) and the institutional mechanisms (e. g. Panchayat Raj Committees) or joint forest management committees that would shoulder these responsibilities (Achar, 1997, this volume).

Human Resource Development

The programme was initiated with a discussion meeting consisting of nearly 60 potential participants in Bangalore on April 1994. Since then, the network is holding 3 day workshops every 6 months, for all the teachers and a few of the students involved. The investigators report their progress during the concluding period and declare plans for the next phase. These workshops are also used to expose the audience to a few experts. Some of the teachers and students also get benefited by training programmes within the country or abroad (Gadgil, 1996b). The experts from IISc and other institutions keep visiting the localities alongwith study teams for monitoring the performance of the college teams as well as guiding them in the field and lab alike. Besides, the participants are provided with a lot of background literature and analytical software packages.

Diversity Diffusion across Habitats

The studies threw light on interesting and little explored patterns of distribution of diversity. We assigned conservation values to species based on their nichewidth measured in terms of their geographical distribution and habitat preference. For instance, one of the thumb rule is that species with wider niche have lower conservation value than the narrowly distributed and habitat specialist species. Composite conservation values of each sample i.e. a transect or a vegetation type or area was determined using the values of constituent species (Pramod et al, 1997a). The biological sampling brought to the fore some important and less known aspects of covariation of biodiversity.

The peak abundance or diversity or conservation value was recorded in very different habitat types for various groups of plants and animals. For instance, butterfles were most diverse in the evergreen forests (Kunte et al, in press), trees in the semievergreen forests (Utkarsh et al, in press), birds in the moist deciduous forests (Pramod et al, in 1997b), herbs in grasslands (Bhat, this volume), aquatic insects obviously in waterbodies, whereas the endemic area of caecilians (legless amphibians) in arecanut plantations (Bhatta, 1997 this volume). Further, diversity, abundance and conservation value for a given taxonomic groups did not have necessarily overlapping distribution. Thus, butterflies were most abundant in the deciduous forests although their diversity was highest in the evergreen forests. The birds were most abundant in deciduous forests, but their diversity peaked in the evergreen forests whereas the maximum conservation values were observed in the shola (i.e. high elevation, montane evergreen) forests.

Regional Dispersion of Diversity

The distribution of diversity is not only diffused across taxonomic groups or landscape but is found to be only weakly correlated with the geographic or climatic gradient. The length of the dry season uniformly increasees i. e. climate becomes drier and drier as one proceeds from southern to northern Western Ghats. One might expect the diversity to peak in the south and gradually fade northward, just as at a global level the diversity is maximum towards the equator where moister conditions prevail. The actual distribution of various organismic groups depart from such trends. The tree communities are most diverse not near the Agastyamalai, the southern tip of the Western Ghats with shortest dry season but near Annamalai foothills in central Kerala (Utkarsh et al in press).

The butterfly and herbaceous plant communities are seen to be more diverse around Nilgiri mountains, north Kerala (Bhat, this volume and Kunte et al in press). The fish and aquatic insect communities record peak abundance or diversity in the even more northern areas such as Karnataka (M. Arunachalam and K. G. Sivaramakrishnan, pers. comm.). Given that the diversity across plant and animal groups is not highly concentrated in few pockets or regions, we need to move away from the prevalent hotspots based or pristine forests ecosystem based approach. We should try to understand and propagate how the conservation of the overall landscape at all the possible places across all regions might help biodiversity maintenance and evolution.

Eroding Social Concern

Biodiversity of the Western Ghats has been variously influenced by humans since thousands of years (Chandran, 1997, this volume). We tried to reconstruct local ecological

history, probing older individuals, gaining insights into the past up to a few decades or centuries, as a part of the biodiversity register programme. We also attempted to understand the ongoing changes in the landscape, its impact on biodiversity and the socioeconomic driving forces behind these. The revelations were shattering, as they falsified the notion of increasing popular support for biodiversity (Achar, 1997). This erosion of concern of biodiversity is seen across most social sectors, including those who intricately depended on it for their survival and even revered and conserved it, till recently (Bhat, 1997).

There are several reasons why grassroots communities who might be the potential stake holders in biodiversity utilisation and conservation be termed indifferent to or against it. The forceful and unjust relocation of tribals and farmers for establishing wildlife sanctuaries and national parks, as practiced till recently agitated local communities a great deal. An atmosphere of suspicion prevailed where people were not sure if they would use natural resources prudently, they can continue to do so in future too. Faced with the threat of government misappropriation of their belongings, they have lost genuine stake in sustainable use, unlike earlier generations (Bhatta and Bhat, 1997).

Besides threat of evacuation around protected areas, severe restrictions were imposed by the government on usage of natural resources by local people. This did not stop or minimize the forest harvests but only added to peoples livelihood costs as now they had to increasingly bribe the forest guard. Even those actively involved in the painstaking and risky job of forest produce collection and selling, can barely fetch prices equivalent to daily wages, while the contractors and industries make enormous profits (Bhat, 1997). As the market demands keep shifting from one species to another form and changes from year to year, very few species yield assured income, that too only limited. On the top of all this, outsiders encroach and ruthlessly over-exploit natural resources, often with the political backing (Achar, 1997 this volume; Poojari, 1997). So motivation of local nature harvesters for sustainable extraction has hit an all time low (Bhatta and Bhat, 1997).

Development Aspirations

While the natural resources are fetching low returns and ensure little security, several alternative economic options have opened up. The forest produce collectors can now partly or fully switch over to farm labour or road labour or industrial labour in the growing township nearby (Pandit, 1997). It requires much less of skill and also offers lower risks, better returns. As communication facilities have reached even remote areas, most people desire to avail civic amentities like road, water, electricity and even television, automobile or two wheelers. They find biodiversity contributing a little to fulfill these developmental aspirations, while

education might help them fetch these facilities. So children are increasingly getting educated in schools and colleges and have largely given up going to forests and rivers unlike their elders (Pandit, 1997).

As the rural youth migrate to cities for employment, they have little interest in protecting natural landscape in their village. Nor does the younger generation posses the intricate practical ecological or medicinal knowledge that their ancestors had evolved and maintained and applied over generations. With the passage of time, the older generation, its exclusive knowledge and the concern for nature is also gradually evaporating even as the younger generation fails to realize these values and associated losses (Achar, 1997; this volume).

People's rights and responsibilities

During the process of documenting biodiversity registers, people belonging to various social sectors suggested several ways of creating genuine social stake in the conservation. They emphasized that the government recognizes conservation as comprising of not only protective measures but also ways of regulation and sustainable utilisation, to be implemented outside as well as within 'protected' areas. People also demanded that the rights to manage biodiversity should be vested not with any central or state government body but a local committee. The committee could consist of villagers, officials and even outsiders, but should represent the different user groups and habitations or hamlets well (Bhatta and Bhatt, 1997). The committee would be responsible for annual stock taking and planning of the biodiversity. This might shift the responsibility as well as future costs of over exploitation entirely to the people, in which case they are more likely to ensure sustainable utilisation for their own posterity, as compared to the present regimes of state ownership over forests and waters. The committee might entrust the job of field monitoring and drafting plan to any agency such as neighbouring school or college or NGO. Biodiversity registers might serve as an appropriate tool for this participatory planning.

People also demanded that panchayats be auhorized to charge collection fees to traders on biodiversity trade such as non timber forest produce (Bhatta and Bhat, 1997). The committee should also be empowered to grant permissions to outsiders for harvesting bioresources from the panchayat boundaries, and reserve the right of their temporary or permanent exclusion (Achar, 1997; this volume). The trade should be organised on a more equitable basis such as local, self sustained cooperatives rather than through the ongoing monopoly purchase by the contractors linked to the forest department (Bhat, 1997). The terms and transactions of the trade should be open and transparent, they should be documented in the Biodiversity Registers (Bhatta and Bhat, 1997). In turn, the annual biodiversity monitoring process should

assess and warn against any over exploitation of natural resources as well as the unjust social distribution of benefits, if any.

Biodiversity - Friendly Development

The collection fees charged to the traders might be deposited in a Panchayat Biodiversity Fund that could be used to spend on developmental works like maintenance of roads, schools, irrigation and electricity equipments etc. Hence, all social sectors might start benefiting from biodiversity and in turn may be motivated to ensure its conservation and sustainable use (Achar, 1997 this volume). They would also start realizing the value of biodiversity and attempt to protect it from being underestimated and bulldozed by the prevailing development policies which tend to be exploitative and short sighted. For instance, if people are willing as well as as authorized to ensure that the timber is not smuggled out of the panchayat and if they realize the multiple values of the trees, a road cutting through the forest may not necessarily provoke illegal and excessive biodiversity harvests, as people may try to check it more effectively. The development would then turn out to be much more biodiversity friendly than today.

A significant contribution to the village development should also come from the state and national biodiversity funds. These could be enriched by levying a Conservation Cess on all biodiversity based products like pickles, jams, syrups, cosmetics or medicines (Anon, 1996). Additionally, industries could be made to contribute a part of the royalties they earned through patents based on research triggered by the grassroots knowledge of folk medicines or cosmetics or traditional crop varieties.

Such conservation funds can be used to reward knowledgeable individuals or nature enthusiasts for their contribution to knowledge documentation or conservation efforts (Anon, 1996; Gadgil et al, 1996). Such rewards or social honours through felicitations would also motivate the younger generation to learn more about nature and its conservation. Additionally, if they are engaged effectively in nature studies as a part of their curriculum, they might start giving the much desired importance to biodiversity in their world-view and in particular, their emerging development perspective.

Information and Benefit Sharing

The Article 8 of the International Convention on the Biological Diversity (CBD) of which India is a signatory country, binds us not only to obtain prior consent of the local communities for accessing their knowledge, but also to equitably share with them the benefits arising out of its commercial applications. Biodiversity registers form an excellent foundation

to evolve such a mechanism. These registers could be computerised at taluka or district level and information can be compiled and transferred at the state or national level. This information on biodiversity levels, uses, trade volumes, prices, conservation efforts and efficacy etc. from any part of the country can be made available to the local people free of cost but on demand (Gadgil et al , 1996). The industries may be permitted to access this information by charging then reasonable fees. For ascertaining claims of special knowledge or obtaining seed material, they may contact the respective individuals or communities, panchayats and get into an information or material transfer agreement (ITA or MTA) registered with an appropriate government body, with reasonable payable fees. The governments should establish district, state and national biodiversity cells to coordinate these activities (Anon, 1996).

Policy and Legal Measures

The proposed National Biodiversity Conservation Act should incorporate these provisions and the subsequent policy prescriptions as well as action plans should contain details of operationalising such a pro-nature, pro-people and pro-industry strategy. The National Patent Law (1972) should be amended to permit human communities to file soft patents on lead knowledge, just as industries are granted hard patents on the advanced research. The Patent Law should also make it mandatory that pharmaceutical, seed and other such industrial patent applications reveal the details of source of biodiversity material or published or oral, private or community knowledge, if any. Misleading revelations, detected through later research should attract penal provisions.

The Wildlife Act (1972) must recognize peoples rights over natural resources within wildlife sanctuaries and national parks. The Panchayati Raj Act (1992) and the Bhuria Committee report, under the 73rd constitutional amendment, even vest the ownership of the nontimber forest produce with the tribals. Of course, all these rights and authorities should not be conferred without making various social sectors accountable to each other, so that they evolve a check and balance mechanism favouring sustainable utilisation. The biodiversity registers form the basis of such an accountable system.

Biodiversity Education

Such a broad based srategy would hinge on the involvement of educational institutions in collaborating with grassroots people for biodiversity monitoring. This would require changes in educational curricula so that these exercises become part of regular theory and practical syllabi, wherein biology students are rewarded with academic credits and prizes for competitive performance. Towards this end, the Indian Academy of Sciences has launched Project

Lifescape (Gadgil, 1996a) to honour late Dr. Salim Ali on his birth centenary. The project would attempt to publish illustrated, simple, attractive and user-friendly field guides on over 6000 species, families and orders of various important plant and animal groups, keys for their reliable and easy identification. Once this information is compiled, it could be availed as loose sheets, regionally or taxa-wise sorted books, manuals for teachers and students, in the printed form, on computer discs, CD-ROM and the internet. This would greatly enhance the nature literacy in India.

The Indian Academy of Sciences has also begun to experiment on inclusion of these exercises in educational curricula. Admittedly, there could be problems about organizing field trips, evalution of the project work, quality of the results and its implications for managerial applications etc. Above all, people might question the willingness and sincerity of the teachers and students to undertake such an outwardly exercise. However, the Western Ghats Biodiversity Network has successfully overcome many of these difficulties, despite this being an extra-curricular activity, with no academic incentives, even with inadequate reference material. Further, a group of 10 autonomous colleges in Tamil Nadu has come forward to accommodate these aspects in their syllabi (Gadgil, 1996a). This group as well as 50 other colleges from the states of Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh and Orissa are launcing biodiversity monitoring projects over the Eastern and Western Ghats under the guidance of expert group of the Ministry of Environment and Forests, Government of India. There lies the hope that these ideas would soon catch up and turn into a nation-wide movement.

Acknowledgements

I am indebted to Prof. Madhav Gadgil, who initiated these ideas and all the teachers, students and village participants in the Western Ghats Biodiversity Network, who brought these idea to life. In particular, I thank Drs. K. P. Achar, M. Arunachalam, Shonil Bhagwat, Dayanand Bhat, Harish Bhat, K. G. Bhat, G. K. Bhat, T. S. Channesh, D. Daniels, R. J. R. Daniels, K. N. Deviprasad, Arvind Hebbar, Krishnamegh Kunte, Yogesh Gokhale, M. R. James, G. S. Jayadeva, K. S. Madhav Rao, N. A. Madhyastha, Parvathi Menon, K. Murugan, Harini Nagendra, Ramakrishna Palat, Prakash Pandit, C. K. Poojari, M. K. Prasad, P. Pramod, V. S. Ramachandran, V. V. Sivan, K. G. Sivaramakrishnan, M. D. Subhash Chandran, Winfred Thomas and K. Venkataraman. We also thank Drs. S. Adiga and P. G. Diwakar of the RRSSc, Bangalore. The support for these projects came from Ministry of Environment and Forests, Government of India, the PEW Foundation, Biodiversity Conservation Prioritisation Programme of the W. W. F. - India in collaboration with the Karnataka State Council for Science and Technology and the Indian Academy of Sciences.

References

Achar K. P. 1997. Documenting Peoples Knowledge and Priorities for Biodiversity and Conservation through People's Biodiversity Register: A case study of Mala Village Panchayat, Karkala Taluk, Karnataka. W. W. F. - India, New Delhi; KSCST, Bangalore and Bhuvanendra College, Karkala.

Anon. 1996. Report of the Subgroup People's Biodiversity. Karnataka State Planning Board. Bangalore.

Bhat D. 1997. Documenting Peoples Knowledge and Priorities for Biodiversity and Conservation: A case study of Kalase Village, Sirsi taluka, Karnataka. Sahyadri Parisara Vardhini Yedahalli; KSCST, Bangalore and BCPP, W.W.F. - India, New Delhi.

Bhat Harish (this volume). Herb Species Diversity of the Western Ghats.

Bhatta G. K. 1997. Caecilian Diversity of the Western Ghats: In search of the rare animals. Curr. Sci. (73) 2: 183-187.

Bhatta G. K. and P. Bhat. 1997. Documenting Peoples Knowledge and Priorities for Biodiversity and Conservation: A case study of Merkal village, Sringeri taluka, Karnataka. JCBM College, Sringeri; KSCST, Bangalore and BCPP, W.W.F. - India, New Delhi.

Caulinvaux P. 1995. Ecology - 2. John Wiley New York.

Deviprasad K. N. 1997. Documenting Peoples Knowledge and Priorities for Biodiversity and Conservation: A case study of Subramanya village, Sullia taluka, Karnataka. NM College, Sullia; KSCST, Bangalore and BCPP, WWF - India, New Delhi.

Gadgil M. 1996a Deploying Student Power to Monitor India's Biodiversity. Curr. Sci. (71) 9: 688-697.

Gadgil M. 1996b Documenting Diversity: An Experiment. Curr. Sci. (70) 1: 36-44.

Gadgil M. 1997. Diversity: The Cornerstone of Life. NSCST - Hornbill Series on Nature Books, Bombay Natural History Society, Mumbai.

Gadgil M., Subhash Chandran M. D. S., Pramod P., Utkarsh G., Thomas W., Menon P. and Gokhale Y. 1996. People's Biodiversity Register: Documenting India's Wealth. Amruth, 1 (5): special supplement, pp. 1-16.

Gadgil M. and Rao P. R. S. 1995. System of positive incentives to conserve biodiversity. Economic & Political Weekly (Aug. 6): 2103-2105.

Ganeshiah K. N., Uma Shankar R. and Bawa, K. S. 1997. Diversity of species assemblages of islands: Predictions and their test using species of composition of shola fragments. Curr. Sci. 73 (2): 188-194.

Gokhale Y., Welankar R., Chandran M. D. S. and Gadgil M. (in press). Sacred Woods, Grasslands and Water Bodies as Self Organised Systems of Conservation. Proceedings of UNESCO Conference on Sacred Groves. JNU, New Delhi.

Heywood V. (ed.) 1995. Global Biodiversity Assessment. Cambridge University Press. pp. 1200.

Kunte K., Joglekar A., Utkarsh G., Pramod P., Joshi N. V. and Gadgil M. (in press). On the Diversity of Butterfly communities of the Western Ghats. Curr. Sci.

Nagendra H. and Gadgil 1, M. (1997). Remote Sensing as a Tool for Estimating Biodiversity. J. Spacecraft Tech. 7 (2): 1-9.

Pandit P. 1997. Documenting Peoples Knowledge and Priorities for Biodoversity and Conservation : A case study of Holanagadde village, Kumta taluka, Karnataka. A. V. Baliga college, Kumta; KSCST, Bangalore and BCPP, WWF India, New Delhi.

Pramod P., Joshi N. V., Utkarsh G. & Gadgil M. (1997a). On the Hospitality of the Western Ghats Habitats for Bird Communities. Curr. Sci. 73(2): 122-127.

Pramod P., Daniels R. J. R., Joshi N. V., Gadgil M. (1997b). Evaluating Bird Communities of the Western Ghats to Plan for and Biodiversity Friendly Development. Curr. Sci. 73(2): 156-162.

Poojari C. K. 1997. Documenting Peoples Knowledge and Priorities for biodiversity and Conservation: A case study of Neralekoppa village, K. P. Pura Taluka, Karnataka. Visvesvarayya College, Bhadravathi; KSCST, Bangalore and BCPP, WWF-India, New Delhi.

Soule M. (1986). Conservation Biology: The Science of Scarcity and Diversity. Sinauer Associates, Sunder Land, Massachusetts.

Utkarsh G., Joshi N. V. and Gadgil M. (in press). Assessing the Tree Diversity of the Western Ghats. Curr. Sci.

THE PHILOSOPHY OF SCEINTIFIC RESEARCH

Dr. Arunachalam Kumar
Professor of Anatomy,
Kasturba Medical College, Mangalore

Introduction

Which came first? The chicken or the egg ? This philosophical catch -22 question often crops up in scientific circles, when the boundaries of inquiry coalesce into the twilight zone, and into philosophic conundrums. Some years ago I chanced upon a III std science textbook. In one chapter which elaborated on the essential need for oxygen to life, an experiment enjoined the 7-8 year olds to trap 20 ants and bottle them in sealed containers. In hours, the book mentions, all ants would be found dead, proving that oxygen was absolute to life. This is State prescribed text, approved by the Education Department. On one hand we teach our future generations to kill in the name of science, and then blame that very generation when violence, mayhem and indiscipline manifest. All this in the land of 'ahimsa'. What conservation for all living things can be ever taught at teenage level when at under ten stage the future citizens of India have been schooled to think along lines of infringement of animal rights. The green movement that espouses wider acceptance of it's causes not once protested against this experimental exercise taught to children, yet talks from hoary fora on preserving the flora of the Western Ghats for posterity. Hypocritical indeed. Which comes first, the chicken or the egg ?

I noticed some time ago, that in the Nilgiris, the Magpie robin (*Copsychus saularis*) appeared to be slightly different in it's colour permutation than it's coastal counterpart. Promptly, a senior naturalist opined that it could well be the *C. erimelas*, last seen in East India, probably not lost, as was presumed. Why not collect the specimen and send it over for identification and classifying ? .

Inspite of my science scholarship, I was mortified. Just for taxonomic purpose could a museum or a scientist in ornithology slaughter a bird, skin it, stuff it, number it and catalogue it? What if that very Magpie robin was the very last one alive ? Who cares ? I do. For me, love of nature extends to beyond the glass cabinets. It transcends the need to have

a specimen named after me. It is absolute nonsense to kill a Double Banded Courser (the very last) in order to prove it lives.... which comes first, the chicken or the egg ?

Another area where I have my peeves is the one that dictates to promoters of scientific knowledge dissemination, that playing safe has better rewards. A shying away from debating on causes that may tread on some bigwig's corns is common among seminar sponsors and organisers. No symposium was ever held to discuss the merits or demerits of 'tiger collaring'. Everyone in the green business knows why, but mum is the word. Were it not for Darwin, or Copernicus, or Dubois, and their then controversial theories, the scientific world would have remained poor. Most, if not all, seminars now are co-sponsored by industrial houses and 'teakquity' speculators, who dictate the seminar's contents. How can truth be debated, when the voice in the wilderness remains unheard ?

In this brief presentation I shall elaborate on two hypothetical conjectures, that if not anything, may stimulate you to a lively discussion. Both are Western Ghat oriented and this platform is the best one, I could think, to expound on them. Bear with me if I sound preposterous or appear depraved. Science must listen, analyse, debate and then conclude. Rationality is the key.

The Missing Link..In The Western Ghats ?

Human evolutionary tree is notorious for one lacuna. The 'Missing Link' that bridges the ape to early homo. But what has the Western Ghats do do with this ? Well ...it is a long story.

With the break up of the unitary continent of Pangeae about 35 million years, and before the continental drifts redefined the shape and size of seas, oceans and land masses as we know them now, a unified south land mass, broke away to form the Gondwanaland. This mass, comprised of Africa, America (South) ?, India, Madagascar, and Australia (?). In Oligocene, this mass was home to early mammals that included, those that directly led to evolution of Pongids and man. 25 million years ago, the *Aegyptopithecus* and *Propliopithecus* roamed a belt along the Gondwana. Anon, this fertile and habitable strip running across the African equator across North African Deserts, towards India, across to Indochina. Here lived and died, *Gigantopithecus,* the *Ramapithecus* and the *Sivapithecus,* all proconsuls. Then the continental drifts and missing years (about 20 million of them), thence to discovery of the Java man, Peking man, Tuang Baby, *Australopithecus* et al, all dating to 5 million years or less. What happened during the intervening 15 million years.... constitutes the missing (fossil) link.

Where would you start your search for this fossil of early man, Africa ? already shown to posses fossils of later era, or elsewhere ?

I would, at the Western Ghats of India. The part of the range that once, in Gondwana epoch, abutted with Central Africa, Madagascar and Arabia... that is that part of India that once harboured the *Ramapithecus* and *Sivapithecus,* along the north edges of the Western Ghats, and then due east across the Indian fringes, where from the land is contiguous with the Sivalik and Aravalli ranges. Why ? For one, this point in the ghats, if mapped on the Gondawana scenario, abuts Equatorial Africa on one side, then continues with the land mass along the present foothills of the Himalaya, along Burma, Indochina and Indonesian archipelago, onward of Northern Australia. Note too, right along the belt, now dilineated, still live, the oldest tribals in modern world, the nomadic ones of east and South Africa, the Anadamanese, the Jarawans, the Sentinelese, the tribes of Philippines and deeper tropical forests of Indonesia. Their presence along this narrow strip spread today over three continents (inclusive of the aboriginals of Australasia), falls precisely over the land bridge that harboured early man, and protohominids. In fact so coincidental is the hypothesis with the frequent reports of sightings of the abominable snowmen or yetis, or the giant men, big foot etc. from Vietnamase forests,that I am convinced remnants of *Dryopithecus,* or *Gigantopithecus* may remain. If so, could not the first *Homo* fossils be found here too ? They will be. I have no doubt, some day, some enterprising anthropologist will unearth, fossils of the 'Missing Link' or even some skeletal remains of *'Australopihecus*-like' *Homo* fossils from the Western Ghats of India. Our Ghats are not only a rich repository of floral and faunal wealth, but one day may become the Mecca for fossils and play a role in completing the tree of human evolution, and fill the blank that has puzzled scientists for decades. Where would one find the connecting link between ape and man ?.

Chimpanzees and Gorillas of Africa, Gibbons in Assam, and Orangutans of Sumatra and Borneo. How else could one explain the spread of these primates along such distant lands except through assuming that the gene pool and evolutionary tree of these animals diverged from one small focal mass in Gondwanaland. Gene and RNA, and genetic code are mathematical constants over millinea, except by mutation, gene structure function cannot alter. Could not the early gene that spawned *Homo* as a species have also originated over one small zone ? And could that zone not be ascribed as of Indian origin, in Western Ghats of today ?

Oligocene

25 million years

Propliopithecus

Dryopithecus

Gigantopithecus

Ramapithecus

Sivapithecus

Mesopithecus

All these ranged across the present from East Africa to North West India to Indochina, some reports show them spread into Mediterranian Europe.

The interlink between these early protohominids is missing. Fossil hunting should be made across the very range where these Pongidae lived and died, and this will include the north of Western Ghats, east of Kutch.

The Need For A Manmade Shiradi Gap

Extending all along the west coast of India and slightly beyond the Western Ghats forms a near unbroken chain of low-high range that forms an effective rain shadow to the southwest monsoons. From late May to early September, the rain bearing clouds borne over the Arabian Sea, sweep across the coast, bringing in their wake, a deluge. The annual rain fall, collated for this monsoon period, totals an amazing 2000 to 7000 mm, west of the ghats. The peak cataract averaging about 4500 to 5000 mm pours between the Kannur-Kanara(S)-Agumbe-Shiradi.

Some years ago, a maverick Karnataka Minister of Forests, opined that if somehow scientists could harness this gigantic inundation, which in the main, passively meanders towards the sea, the drought prone peninsular Deccan India could possibly benefit. He suggested that, were a segment of the ghats flattened, then perhaps, the monsoon bearing clouds could be channeled over the Deccan, and feed the river catchment areas and basins, solving for ever, the annual visitation of water scarcity. His plan was derided and scoffed at.

Look again at the proposal dispassionately. Is it is as harebrained as it sounds ? To me it makes perfect scientific logic. If man is the apex of the evolutionary tree, then his welfare should be paramount. Erasing a 10 to 20 km of the ghats, could well funnel rain, by directing the westerlies into this artificial gap. Even a few cm of rain, is panacea for some parts of hinterland Karnataka. Is the Western Ghats so sacrosanct that it's partial

displacement is construed to be blasphemous ? Why, for the Konkan Railway a million tonnes of earth had been excavated from the very hallowed ghats with nary a protest. So what's the harm in creating another Palghat Gap like sceario to benefit mankind ? Yet, to my understanding, no scientific body ever organised a seminar or symposium on this amazing proposal. Why does the environmental scientist feel that even debating such themes are taboo, or heretic ?

Come to think of it, a century ago, another maverick did sever the American continent into northern and southern halves by laying Panama Canal.. or another bifurcated the African Continent from Europe by dredging the Suez Canal. Harebrained schemes ? Why, even our mythological texts mention of a manmade land bridges laid across the Indian Ocean to Lanka, or of a hatchet heaved across the Arabian Sea to reclaim land, the very Parashurama Kshetra we are today talking from. Geological manipulations for man's benefit is not a new idea. It is as old as history. Decades ago, another senior ecoscientist auggested linking Ganga to Cauvery. Today, the idea is eminently operational, and part afoot: The Krishna is linked to Cauvery by man.

Science is plastic and should remain so. Ascribing a 'touch-me-not-status' to the ghats is counterproductive to progress, and not even debating on the pros and cons of ideas such as these, is, to me, nothing short of an 'ostrich head in sand' attitude.

A 500 meter decrease in the ghats at about the Shiradi base, would serve to channelise the eastward sweep of the clouds to the hinterland. This break in the continuity of the ranges may not effect the biozone too severely, on the contrary it may serve to augment the resurgence of green cover beyond the ghats on the western edges of the Deccan plains. Certainly it would cost billions.. but the effort will be well worth.

Discussion

The need for introspection and review of the stand biologists take of day to day problems affecting mankind and his environment is imperative. Playing to the gallery, by espousing safe and accepted causes, and shunning away from controversies, has weakened the green movement and allowed it's fora to be hijacked by pseudo-enviromentalists with vested interests. If anthropocentricity be the issue, then let us do our bit, at any cost, to enrich the quality of life on earth, with man at the apex of the evolutionary tree.

Two theories have been proposed in this paper: one which surmises the possible chance of discovering the remains of early hominid or even the 'missing link' in the Western Ghats,

especially in it's northern fringes, and the second that scientifically analysised the pros and cons of creating an artificial manmade gap in the ghats along it's maximum rainshadow regions. If these two case theories enthuse even one scientist present here, my paper presentation is well worth the time and ridicule it is bound to generate. I ask only for a hearing.

References

Kumar A-The philosophy of scientific research and chick embryology : Seminar at the Bombay Natural History Society, 1991

Kumar A-The Nilgiris Magpie Robin. Newsletter for Birdwatchers, 1992

Kumar A-Footnotes, Ist Ed.Shreedurga Agencies, 1994

Kumar A-The evolution of man, Canara Times, 1992

Kumar A-The forest cane turtle, Morning News, 1997

On The Ecological History Of The Western Ghats

M. D. Subash Chandran
Department of Botany, Dr. Baliga College of Arts and Science
Kumta 581 343, Karnataka, India.

Abstract

Over three millennia of forest utilisation and management by traditional societies, and the practice of state forestry since last 200 years, have moulded the forest ecosystems of the Western Ghats. Major vegetational changes here began with the migrations of agri-pastoral people, beginning in the middle of 4th millennium (BP) Before Present. The pre-colonial times had mostly village oriented traditional landscape management. Since colonial times, forestry became more state centered, paying scanty consideration to traditional management and to other forces of history which moulded the Western Ghat landscapes. The present landscape and vegetation of the region are replete with reflections of history which may be of great ecological interest.

Introduction

One of the 18 biodiversity hot spots [1,2] of the world, the Western Ghats, together with the West Coast, form an important ecological region. Springing from the Arabian sea coast to the montane heights of over 2,000 m, and having rainfall ranging from less than 1,000mm, to over 6,000mm, the landscape here is very heterogeneous. This paper broadly tracks the ecological history of the Western Ghats-West Coast region, from the days of its first agricultural colonization, over three millennia ago. A blend of history with ecology, this paper also highlights the fact that adoption of an historical perspective may be advantageous to ecologists and resource managers. Efforts are made here to integrate information from diverse fields like archaeology and history, palaeo-ecology, ecology, botany and forestry. Only the central and parts of the southern Western Ghats are covered in this work. The glimpses of history given here are more from a vegetational angle.

Agricultural occupation of the tropical forests

People have been living in tropical forests for millennia and very little of these forests,

if at all, may be "pristine"[3]. Farming here may be less than 10,000 years old, but the pre-agricultural phase of vegetational manipulation to promote favoured food plants by hunter-gatherers is older[4]. In New Guinea, 30 to 40 thousand years ago, human beings were manipulating the forest by trimming, canopy thinning, and ring barking to increase the natural stands of taro, bananas and yams[5]. In Central America, hunter-gatherers were burning the pre-montane forest by 12,000 years ago[6]. The Asian forests were inhabited by hunter-gatheres more than 10,000 years ago[7]. Agriculture existed during the Holocene in tropical and temperate areas alike. Thus around 9,000 years BP, while grains were being cultivated in Mexico and the Near East, New Guinea farmers were draining wetlands for growing taro and some other crops[8].

Pre-historical Western Ghats

The Western Ghats came under first human influences during the Palaeolithic or Old Stone Age, over 12,000 years BP (Figure-1). Stone tools of this period were discovered from the river valleys of Bharatapuzha (Palakkad dt.) Beypur (Malappuram dt.), and Netravati (Dakshina Kannada dt.) [9,10]. In the western Deccan, Palaeolithic artifacts have been found a Kibbanahalli (Mysore dt.), Lingadahalli, Nidaghalla and Kadur (Chikmagalur dt.), and Honnalli (Shimoga dt.) [11-12]. Being hunter-gatherers, Palaeolithic people would not have caused any serious impact on their natural environment.

Mesolithic or Middle Stone Age (12,000-5,000 BP) witnessed the transition of hunter-gatherers into food growers. Many Mesolithic sites have been discovered from Mandovi River in Goa to Kerala, such as Karwar and Ankola (Uttara Kannada dt.), Netravati Valley (Dakshina Kannada dt.), Nirmalagiri (Kannur dt.), Chevayur (Kozhikode dt.) and Tenmalai (Kollam dt.) [9,10,13]. Charcoal of 5,000 years BP, got from trenches in Tenmalai, indicates that the people could have burned forests.

Early agri-pastoralism in the Western Ghats

During the Neolithic or New Stone Age (5,000-3,000 years BP), the Deccan Plateau was waking upto primitive agriculture and pastoralis [14]. In Hallur (Dharwad dt.), close to the Western Ghats, cattle, sheep and goat were domesticated 3,800 years BP, and millet and horse-gram cultivated 300 years later[15]. The Jorwe people of Inamgaon, in the western Deccan of Maharashtra, had irrigated rice during 3,400-2,700 years BP. The Jorwes bought marine fish haematite and shells from the Konkan coast, 200 km to the west[16]. This shows that the Neolithic people of Deccan had some knowledge of the Western Ghats and the coast. Some of the many Neolithic sites in the Western Ghats are Tambde Surla (Goa),

Anmod (Uttara Kannada dt.), Agumbe (Shimoga dt.), hill slopes of Sita River (Karkala), Kodagu and many others in Kerala [9,10, 17-19].

The Nilaskal site in Agumbe, being close to the sources of West Coast rivers Sharavati, Chakra and Haladi, was strategic to the Neolithic people, giving them an easy access to the coast. According to Sundara[13], Neolithic people with their stone axes descended from the Western Ghats of Dakshina Kannada to the coast, in the last part of the 4th millennium BP and resorted to cultivation, probably by slash and burn method. Similar westward migration of Neolithic agri-pastoralists from the Deccan could have taken place elsehwere too. Hill cultivation (presumably shifting) in South India may be older to the spread of iron tools here, about 3,000 years back[20].

During the Megalithic Period (3,000-2,000 BP), iron implements were widely used. Use of iron dates back to 3,500 years in Hallur[15]. The West Coast of South India was intensely settled during this Period. Numerous Megalithic burial sites are associated with chambers dug in lateritic plains of the West Coast in Karnataka and Malabar. The Megalithic Period would have witnessed intensification of forest clearance by agri-pastorals. The torrential rains of the region would wash away exposed soil from hills and plateaus, exposing the laterite and hastening its weathering. The excavated burial chambers in laterite plains were found in Malabar, Dakshina Kannada and also in Siddapur of Uttara Kannada [13, 21].

Fourth millennium BP vegetational changes in the Western Ghats

A palynological study based on a marine core from Uttara Kannada, by Caratini *et al.* [22], shows that about 3,500 years ago there occurred a sharp increase in savanna pollen, mainly from grasses, and a decline of pollen from evergreen and deciduous forest plants, and mangroves. These changes have been attributed to the onset of an arid climate.

A study in the peat bogs of montane Nilgiris, by Sukumar *et al.* shows a shift of C3 vegetation (C3 forest/grassland) towards C4 vegetation (grassland), during 6,000-3,500 years BP, due to lower rainfall and lower CO_2 levels. Predominance of C4 vegetation reflects arid conditions and that of C3 vegetation reflects moist conditions[23].

The climatic change theory effectively explains the expansion of C4 grasslands in the montane Nilgiris, during the 4th millennium BP, where during a similar arid spell 20,000-18,000 years BP also such grasslands had existed [23]. But this theory alone may not explain vegetational changes in Uttara Kannada (mean elevation 600 m). Pascal[24,25] considers savannas in the plains and at moderate altitude in the Western Ghats as essentially the result of fire. Gadgil and Meher-Homji[26] consider the savannas of much of the Indian subcontinent as due to human interventions in the woodland ecosystems.

Chandran[27] suggests that the beginning of agri-pastoralism may be the main cause for the 4th millenium BP changes in Uttara Kannada. In fact almost all the forest species, represented in the pollen sample[22], occur to this day in the region. Of these *Dipterocarpus indicus*, an endemic tree of the Western Ghats, occurs mainly in a few sacred groves or *kans* of Uttara Kannada. Its presence in these *kans* may be correlated to decline of primary forests elsewhere due to human factor and its failure to revive in the secondary forests[27]. In Burneo, Ashton[28] noted the absence of Dipterocarps in secondary forests, where tribes had slashed and burned in the past. We should, therefore, also look into contemporary history as well.

Harppan migration into the South India ?

Increased aridity in the climate of Indus Valley, salinity rise in the lakes and drying up of the Saraswati River, during 4th millennium BP, may have caused an upstream migration of the Harappans, towards the Siwalik Himalayas[29]. The Western Ghats region, due to its strategic position, could have still been enjoying a relatively humid climate. The biodiversity rich forests, the abundant water resources, the productive estuaries and the sea, could have attracted the drought stricken Neo and Megalithic agri-pastorals from the Deccan, as well as the Harappans[27].

The Indus Civilization did not perish suddenly according to Dixit. The Later Harappan Phase survived in Saurashtra, Gujarat, north Maharashtra and in the northern states upto 3,200 years BP[30]. Apart from a more benevolent climate and richness of biological resources, other reasons for a suspected Harappan migration into the south are:

1. Late Harappan Culture is said to have intruded into lower Deccan, as far as Daimabad and Upper Krishna Valley in the Belgaum region [31, 32].

2. Harappan Culture was not an horse and chariot based one unlike the Vedic Culture. The suspected objects of worship in the Indus Valley, the Mother Goddess, a male god - considered a prototype of Siva, the humped bull, the serpent etc., bring it rather closer to the Pre-Vedic cultures, whose survivals today are mainly in the mountainous and hilly regions of India. The main strongholds of Saivism, Shakthi (Mother Goddess) worship, snake cults and tree worship are the Western Ghats, the Himalayas and the Central India. The Harappan's was, therefore, not a culture insulated from the rest of, but one which enjoyed continuity with it.

3. The art of making terracotta figures, including of the Mother Goddess, was a cardinal

trait of the Harappan Culture. Many sacred groves of the Western Ghats have a rich deposit of ancient terracotta figures; some communities continue the pre-historical practice of making such figures as votive offerings to their deities. Such figures of the Maurya - Satavahana period were found at Banavasi in Uttara Kannada [33].

4. Wild or semi-wild rice was possibly adopted by the farmers during the Late Harappan phase[30]. The salt tolerant wild rice strains of the West Coast could have been ideally domesticated from 3,500 BP. The rice cultivation in reclaimed estuaries could have perhaps caused the mangrove decline in Uttara Kannada as noticed in the pollen samples[22].

The legend of coastal reclamation

The West Coast could have been, earlier, a maze of hills covered with evergreen forests, estuaries, sandy plains and other low lands. The beginnings of coastal reclamation may date back to pre-historical period, merging with legends and folklores. *Mahabharata, Vishnu Purana and Skanda Purana* state that the Sage Parashurama, standing a top the Western Ghats, threw his axe into the Arabian Sea retrieving the West Coast. Some recent findings, in this context, are significant:

1. The land in and around Karwar contain recent Molluscan and micro-faunal shells. The freshness of the Molluscan shells of Mangalore coast suggests that, "this coast can be considered as an emergent shore[34]."

2. Bourgeon[35] considers the fluvio-littoral plains of Uttara Kannada coast as of recent origin. He observed fossilized mangrove soils under nearly two meters of recent sediments. The ferruginous accumulations that he found in such areas are likely to be derived from the iron rich hill soils used for coastal reclamation. In coastal Uttara Kannada, today, commercial exploitation of Molluscan shells buried underneath the rice fields shells are being carried out.

3. A peat deposit recently discovered in the Arabian Sea, off the Uttara Kannada coast by Mascarenhas *et al.* [36] need to be reexamined in the context of a pre-historical coastal deforestation. This peat was mixed with flaky materials resembling broken twigs. Its high content of organic carbon, iron and aluminium, and other mineral contents similar to the rocks of Uttara Kannada, may indicate that the peat may be a deposit of slashed and burned land vegetation, mixed with eroded land minerals. In fact the savannization of most of the Uttara Kannada coastal hills had taken place before British occupation itself[27].

The Western Ghats in History

The Western Ghats figure early in South Indian history. King Ashoka sent a messenger to spread Buddhism in the Banavasi kingdom in the central Western Ghats, during 3rd century BC[33]. The West Coast had spice trade with Roman empire. References to rice and millet cultivation in the South Indian hills are found in the 2,000 years old Sangam Tamil literary works.

Hill agriculture and community forestry

Early agricultural settlements along the rivers were perhaps also associated with slashing and burning of forests in the nearby hills, for cultivation. The vegetation maps of Uttara Kannada Western Ghats[37], for instance, show that secondary moist deciduous forests occur along the river courses. Ward and Conner, in their memoir of the survey of Tracancore and Cochin States, during 1816-20, mention that each river was rented out for the extraction of teak [38]. Teak and bamboo, instead of the climatic evergreen forests, were plentiful along the West Coast rivers, at the time of British occupation[39,40].

Shifting cultivation in the Western Ghats

The shifting cultivators seem to have normally occupied a zone below 1000m[40], perhaps avoiding the colder and wind-swept heights. Thin human population and long fallows often permitted the return of the forest [39,40]. Buchanan, who travelled through Malabar and Canara in 1801 [41], made detailed studies on pre-colonial land use. At Gokarna he found records of 1450's relating to tax on shifting cultivation. Coastal hills of Uttara Kannada were formed into terraces for cultivation in gingelly and blackgram. In the interior hills, in the first season after burning the woods, were sown ragi (*Eleucine coracana*), red gram (*Cajanus cajan*), and castor *(Ricinus communis*). Next year on the same ground was raised a crop of shamay (*Panicum sumatrense*).

The tribals of Travancore hills planted rice, cowpea, gingelly, tapioca, yams, cucurbits, brinjal, chilli and plantation[40]. Kanis and Arayans planted their surroundings with trees like mango and jack. Each tribe of Travancore hills had a certain tract of country which was considered to belong to it, and no one dared to encroach on the land of another village[40].

Conservation in the pre-colonial days

Indigenous people with a historical continuity of resource use practices often possess a broad knowledge base of the complex ecological systems in their own localities and they do develop a stake in conserving, and in some cases enhancing biodiversity[42]. In the Western

Ghats, forest conservation went hand in hand with utilisation. Hunting was subjected to many community regulations[43].

Amidst the secondary forests and fallows of Travanocre hills, Bourdillon[40] noted: "Many pieces of forests are left untouched when the surrounding land has been cleared... because they are supposed to be each inhabited by some spirit." Forest clearance was inevitable for farming: yet there was an overwhelming belief in the sacredness of the woods. To Buchanan in 1801 the people near Karwar confessed[41]. "The forests are the property of the gods of the villages...., and the trees ought not to be cut without having leave from the Gauda of the village." Secondary species and heavily savannized tracts were interspersed with lofty evergreen patches, the *menasukans* or pepper forests, where the people tended to the wild pepper. The relics of such *kans* occur to this day in Uttara Kannada and Shimoga. They were important pieces of pre-colonial forest conservation in the Western Ghats. Myriad relics of such groves, exist even today all over the Western Ghats. They may be *devrai* in Maharashtra, *devarkadu* in Coorg and *kavu* in Kerala and Tamil Nadu [10,44,45]. These sacred forests, in the pre-colonial landscape, served many functions like conservation of biodiversity and watershed, moderation of climate, and enhancement of landscape heterogenity which promoted varied wildlife. The people had also much reliance on subsistence hunting. The village sacred forests ranged in size from few hectare to few hundred hectares[44]. The *kans* of Sorab taluk in Shimoga, for instance, covered about 13,000 ha or 10% of Sorab's area[46].

Decline in valley forests and freshwater swamps

Rice cultivation in the fertile valleys preceded gardens of early commercial crops like arecanut and pepper. The original vegetation of the ill drained valley bottoms with sluggish streams, in elevations below 1000m would be often a special formation, the *Myristica* swamp[47]. These swamps, though rare, still occur in Thiruvananthapuram[48]; the northernmost *Myristica* swamps are found in the Siddapur taluk of Uttara Kannada[27]. Rare Western Ghat endemic like *Myristica fatua* var. *magnifica*, *Gymnacranthera canarica, Semecarpus auriculata* and a fragile palm, *Pinanga dicksonoii* are found growing in such swamps.

Freshwater swamps in Uttara Kannada were being favoured for conversion into arecanut gardens and fields of summer rice[41]. Expansion of traditional agriculture and the spread of particularly rubber, coffee and forest tree plantations would have wiped out large pockets of primary forests in valleys. *The Myristica* swamps being sources of streams their destruction would have impoverished the water resources of the Western Ghats.

State forestry in the Western Ghats

The British occupation of the Western Ghats, from early 19th century, set the tone for forestry operations to date. Traditional forest management systems did not impress the British. The Madras Government banned shifting cultivation in 1860. The Government of Bombay banned it in Uttara Kannada late in the 19th century. The state foresters failed to link the association of teak and other deciduous timbers in the evergreen forest belt of the Western Ghats with old slash and burn fallows. Troup[49], the silviculturist, in 1921, decades after the ban on shifting cultivation, brought this to the notice of the foresters.

The early forest working plans for the evergreen forest belt of South Indian Western Ghats mainly aimed at the extraction of commercial deciduous timbers, like teak. However, the diminished role of fire as an ecological factor, following the ban on slash and burn cultivation, favoured the return of the evergreens, as in Uttara Kannada. As large teak was harvested, adequate natural regeneration did not follow under the darkening canopy of the evergreens. The rising demand for teak and its depletion in nature made the foresters to initiate massive vegetational changes in favour of teak monoculture[30,51].

The higher altitude forests were, if at all, sparselly populated with tribal people. Following the British occupation began large-scale forest exploitation and wholesale vegetational transformations into commercial plantations of coffee, tea, wattle and Eucalyptus. Such commercialisation of the high altitudes, as of the Nilgiri plateau, marginalised the small populations of the earlier human groups, the so called "ecosystem people" engaged in hunting-gathering, shifting cultivation and pastoralis. The State policies favoured the immigrant "biosphere people", who controlled natural resources in the Nilgiri area, and extracted and traded them in the markets. The spurt in commercialisation of natural resources and commodity production also attracted an exodus of migrant labourers with overall serious ecological consequences on the biota[52]. The high altitudes of Kerala and southern Tamil Nadu also witnessed similar transformations beginning in the mid 19th century.

Decline of the sacred forests

Government reservation of the *kans* of Uttara Kannada as state forests, late in the 19th century, was followed by introduction of contract system for collection of non-wood produce, which replaced the community management[53]. In Shimoga, as the state claimed the timber rich deciduous forests, the people were required to meet their biomass needs from the evergreen *kans*, which they had conserved through ages as safety forests. Not aware of the role of *kans* in traditional land use system of Karnataka Western Ghats, Brandis

and Grant[46] wondered: "Why a certain locality should be covered with evergreen., and anqther in its immediate vicinity with dry forest?" *Kans* were also released for coffee cultivation.

In Uttara Kannada many *kans* were allotted as leaf manure forests to the arecanut growers as well as added to the category of open access 'minor forests', hastening their destruction. After independence Uttara Kannada *kans* were even subjected to timber and firewood harvesting. Under the influence of a cultural change that has been sweeping through the Western Ghats region, the pre-Vedic deities of the sacred groves are related to the deities of organized Hinduism and temples were being errected to house them, the groves suffering in the process [10, 44]. Some notable sides of the state forestry are the restrictions on shifting cultivation, which favoured the return of the evergreens, and the formation of wildlife conservation areas and biosphere reserves.

Decline in plant endemism and evergreenness

Most of the Western Ghat endemic plants are associated with evergreen forests[27, 54]. The Western Ghats also share several plant species with Sri Lanka. A study of 81 sample plots in Uttara Kannada by this author shows that tree endemism, including shared endemism with Sri Lanka, increases with evergreenness of the sample (Figure 3). By evergreenness it meant the proportion of evergreen trees in the total tree population. Slash and burn cultivation, savannization and forestry operations favouring deciduous timbers would have reduced plant edemism in the Western Ghats. The stoppage of slash and burn cultivation, on the other hand, is expected to favour the return of the evergreens[27].

Fire and forests

Fire must have played a major role in the vegetational history of the Western Ghats. Fire affects the regeneration, both directly through the burning of seeds, seedlings and trees and indirectly through its action on the soil by increasing surface temperature, reducing organic matter, modifying soil texture and facilitating erosion. Soil physics and chemistry are also affected and fungi and micro-organisms and soil fauna are destroyed[55]. Slash and burn cultivation in the heavy rainfall zone of the Western Ghats, would have favoured the spread of bamboo and hardy leaf shedding trees with thick bark, lighter seeds and high coppicing and propagation through roots. Examples of the fire tolerants are *Acacia catechu, Careya arborea, Dalbergia latifolia, Dillenia pentagyna, Schleichera oleosa, Tectona grandis, Terminalia* spp. and *Xylia xylocarpa.* Figure 4 shows that the percentage of fire tolerants in the 81 forest samples of Uttara Kannada decreases steeply with increase in endemism[27, 49]. The ban of shifting cultivation favoured the return of the evergreens to the disppointment of the foresters[50].

The use of fire in the past might have caused the destruction of forests on many exposed, wind-swept, medium elevated mountain tops (800-1600 m) as in Kemmangundi, Kudremukh or Coorg in Karnataka Western Ghats. Forests perhaps failed to return here creating stretches of fire-prone grassy patches which are intersperesed with evergreen forests rich in endemism in the folds. These grassland-forest complexes mimic the true shola grassland complex of the montane Nilgiris and the High Ranges of Kerala.

Reflections of history in the woods

Almost every patch of forest in the Western Ghats has its own unwritten history - history of conservation, inaccessibility, exploitation or transformation. The Uttar Kannada study by this author[27], involving 81 sample sites, tries to recapture the dynamism of forest history in a tangible form. In the absence of fire as an ecological factor we may expect 1. A return of the endemics, mostly fire sensitive trees (Figure 4); 2. Endemics are mostly evergreens with thin bark (Figure 5); 3. Increase in mean seed weight of the forest patch - as the canopy gets darker with recruitment of more evergreens, heavy seeded species increase in the community (Figure 6). Primary tree species of tropics, often with animal dispersed fruits, are large seeded, shade tolerant, slow growing and long lived unlike the light seeded and short lived pioneers which thrive in large forest gaps. Late successional trees tend to have heavier seeds [56-58].

Pioneers of large gaps like *Macaranga pelltata*, and *Ervatamia heyneana,* are very light seeded (0.048 gm for both). Teak seed weighs just 0.044 gm; for *Xylia xylocarpa*, a deciduous tree, it is 0.24 gm. The seed of *Dipterocarpus indicus,* a climax evergreen tree, weighs nearly 3 gm. The heaviest seeds of the samples are for *Myristica malabarica* (13 gm). When a forest recovers its evergreenness, the generally light seeded deciduous species are destined to be replaced by heavier seeded evergreens. As the evergreenness increases, coppicing trees (which obviously have accumulated in areas of human disturbance) tend to decline (figure 7) [27].

Forest history in tree ages

Ring count to estimate tree age is considerd inapplicable or unreliable in the tropical rain forests. Nicholson [59] and Rai [60] used annual growth increments to estimate tree ages. Rai's estimates are based on data from forest preservation plots in Karnataka Western Ghats. The annual diameter increment for slow growing evergreen *Myristica malabarica*, for e. g. is only 0.14 cm; that of the deciduous *Terminalia paniculata* is 0.3 cm; that faster growing deciduous tree *Dillenia pentagyna* the d/yr is o.55 cm [61-63]. Although the method is indirect and does not consider the environmental factors, it is useful in unravelling forest history.

In the field studies by this author in Uttara Kannada evergreen forest belt, girth of all the trees in 25 sample plots, each of 1 ha, was measured. The application of Rai's growth increment formulas for trees in these sites shows that, as expected, most leaf shedding tree species regenerate in deciduous forests or in low evergreen areas. In high evergreen forests, the deciduous, if present, are older individuals whose regeneration may be at stake. The estimated ages of the deciduous trees, for instance, provide clues to the forest historian as to when the last major canopy opening took place, favouring the arrival of the deciduous[27].

Figure 8, for instance, illustrates that *Terminalia paniculata*, a light seeded, thick barked, deciduous timber species capable of coppicing regenerates in forest samples where upto 70% of the trees are evergreen. However isolated older individuals may occur in high evergreen forests. The youngest of such individuals fall in the age class of 75-100 years. This is significant historically.

Slash and burn cultivation in Uttara Kannada was almost totally banned towards the close of the 19th century. Since then evergreens are expected to return. On the other hand Figure 9 shows that *Dipterocarpus indicus*, a climax evergreen species of the Western Ghats is present only in high evergreen forest[27]. This finding may be supported by tree ages of key deciduous and evergreen species from individual sample sites (see table 1 and 2). Table 1 is based on a 1 ha site with unknown history where 92% of trees are evergreen. Some important deciduous elements like *Terminalia paniculata* and *Lagerstroemia microcarpa* are found in older age classes (mostly in 200-300yrs). The deciduous trees like *Stereospermum perseonatum* and *Vitex altissima* are more associated with the tree fall gaps of disturbed evergreen forests.

Table 2 shows the ages of key deciduous and evergreen species from another 1 ha sites Kanchimale - a site with known history of slash and burn cultivation upto the close of 19th centuary. Here 89% of the trees are evergreen and mostly found in all age classes. Most deciduous species are aged over 50 years, reflecting the fact that ban on slash and burn cultivation during latter part of 19th centuary has resulted in progressive succession by evergreens and giving very little scope for regeneration of the deciduous. In the absence of any standard universal method of portraying vegetational changes in the complex tropical forests an indirect method based on tree ages may be of some help.

Concluding Remarks

Major human induced ecological changes in the Western Ghats begin with arrival of agriculture and pastoralism. A climatic change towards the middle of fourth millennium BP,

which induced widespread human migrations within the Indian sub-continent, is correlated to decline of forests and mangroves in our focal area. The contemporary archaeological scenario of Deccan also permits us to think of the migration of agricultural man into the southwest India. As primary forests were cleared and coastal marshes reclaimed, people also evolved various conservation measures. However, the process of commoditisation of forests from early 19th century, disrupted this balance of local communities with nature with far reaching ecological consequences. The forest ecosystems do bear the imprints of human actions through history.

A knowledge of ecological history can only improve our understanding of the Western Ghats ecology, particularly forest dynamics, thereby promoting better management practices.

Acknowledgement:

Thanks are due to Prof. Madhav Gadgil for the guidance for conducting this study. Thanks are also due to the Centre for Ecological Sciences of the Indian Institute of Science and the NRDMS Uttara Kannada district centre for the facilities provided. This can be considered as Western Ghats Biodiversity Network contribution number 7.

Table-1 : Estimated age of some deciduous (D) and some evergreen (E) tree species from one ha forest plot in Uttar Kannada

Sl. No.	Tree Species	No. of trees in different age classes (age x 10yrs)						
		<5	5-10	10-15	15-20	20-25	25-30	30-35
1	*Terminalia paniculata* (D)		1			2	2	1
2	*Lagerstroemia microcarpa* (D)				2	1		
3	*Stereospermum personatum* (D)*	1			1			
4	*Vitex altissmia* (D)*		2	4		1		
5	*Olea dioica* (E)	1	2	5	5	8	2	
6	*Diospyros candolleana* (E)	1	9	9	1			
7	*Diospyros ebenum* (E)	1	10	7				
8	*Knema attenuata* (E)		80	81	22	4		
9	*Myristica malabaria* (E)		2	4	4	3		1

* Associated with tree fall gaps of evergreen forests

Table-2 : Estimated ages of some deciduous (D) and some evergreen (E) trees species from one ha forest plot in Uttar Kannada having 89% of evergreen trees Shifting cultivation was reported from the sites during 1850-1890 period.

Sl. No.	Tree Species	No. of trees in different age classes (age x 10yrs)						
		<5	5-10	10-15	15-20	20-25	25-30	30-35
1	*Terminalia paniculata* (D)			1	1			
2	*Lagerstroemia microcarpa* (D)		4	11	2	1		
3	*Stereospermum personatum* (D)*			1	1			
4	*Vitex altissmia* (D)*	1	7	4				
5	*Diospyros candolleana* (E)	15	65	15				
6	*Hopea wightiana* (E)	5	23	7				
7	*Knema attenuata* (E)		74	66	5	2		
8	*Olea dioica*	2	37	26	10		2	

* A gap species in evergreen forest

Figure 1. A time chart showing important events in the ecological history of the Western Ghats, year before present not in scale.

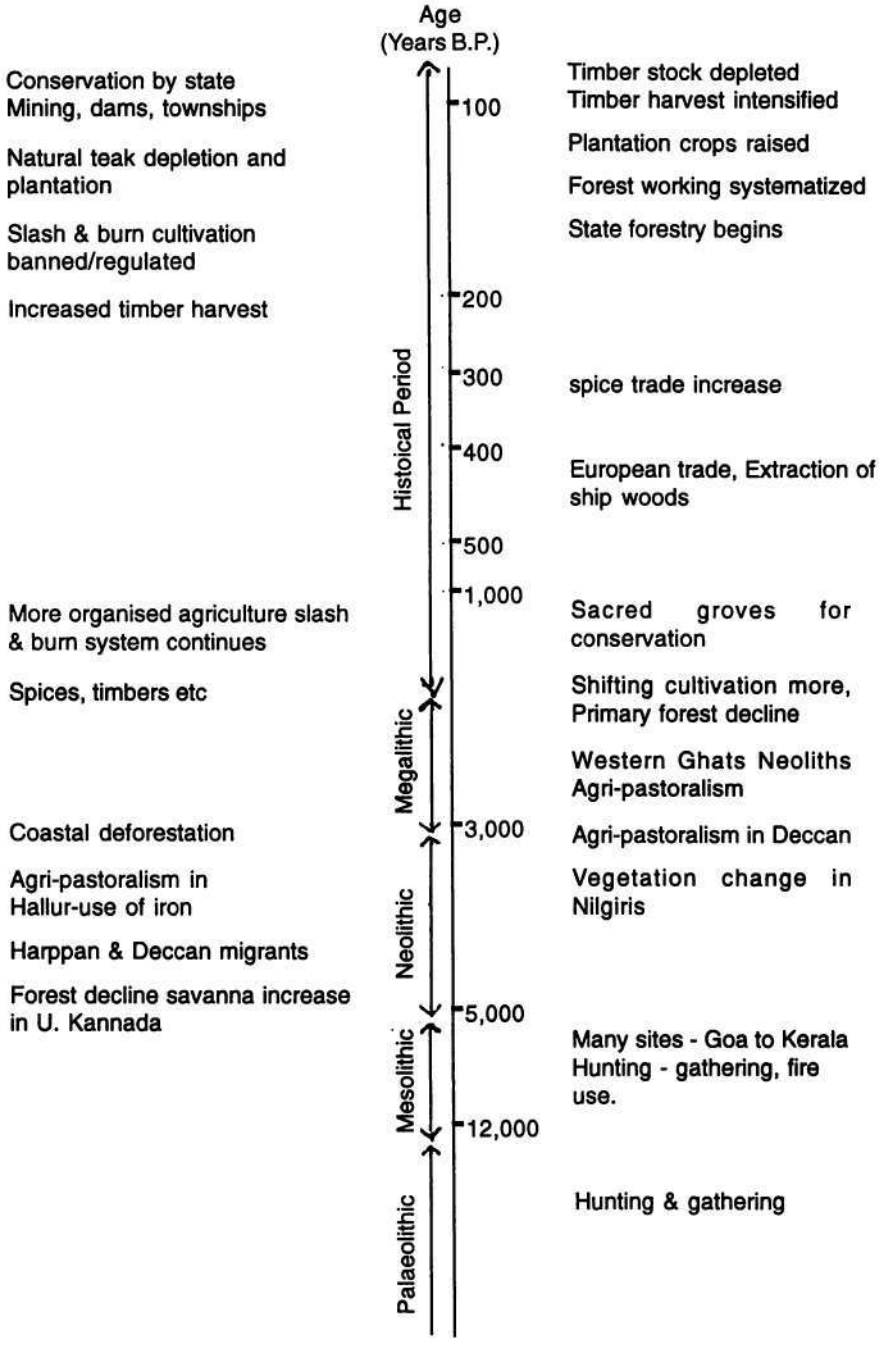


Figure 2. Correlation between evergreenness and endemism For tree population in 81 forest samples in Uttara Kannada.

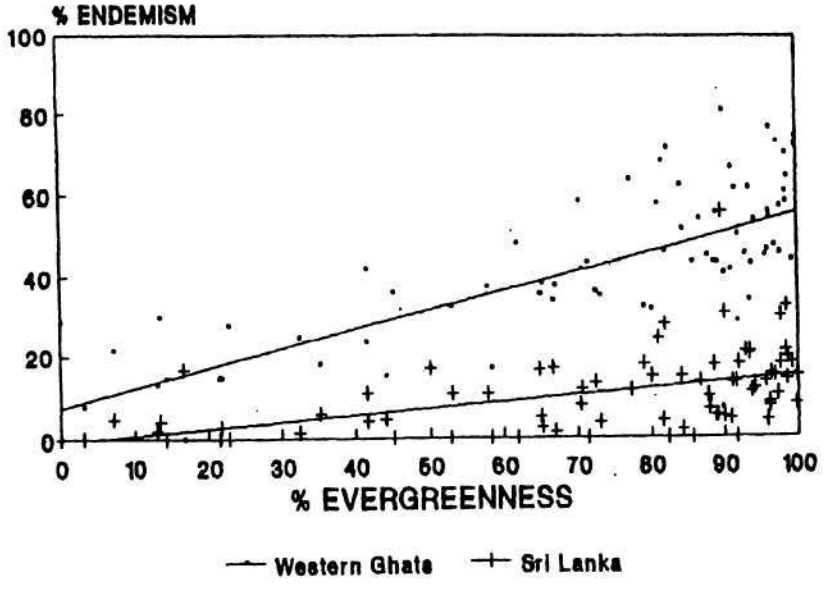


Figure 3. Correlation between endemism and fire tolerance for trees in 81 samples

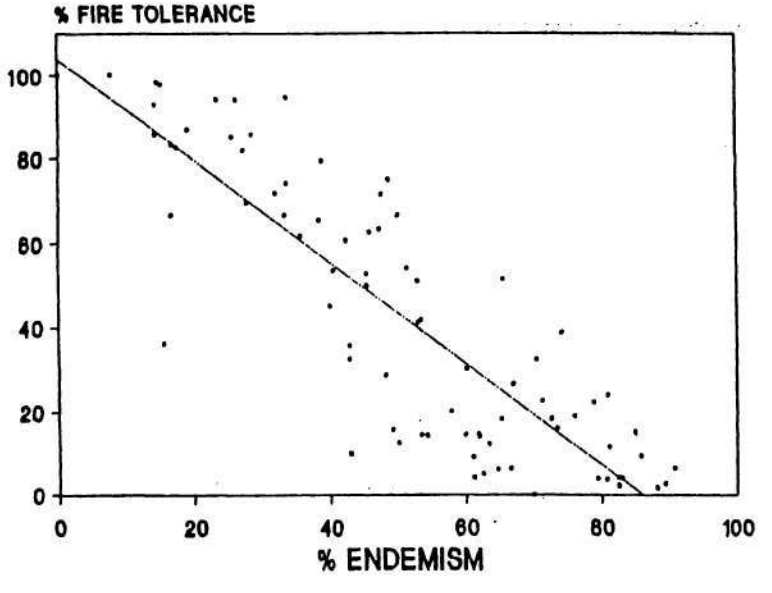


Figure 4. Correlation between endemism and bark thickness for trees in 81 samples

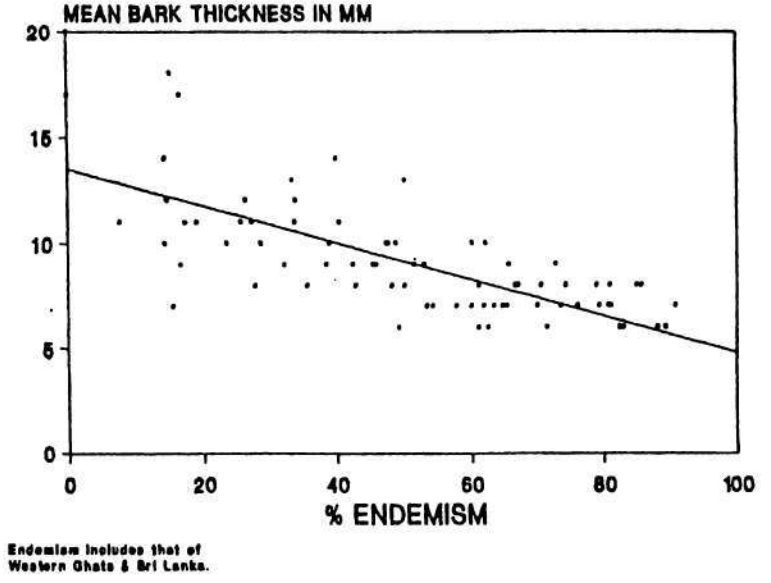


Figure 5. Correlation between evergreenness and seed weight for tree population in 81 samples

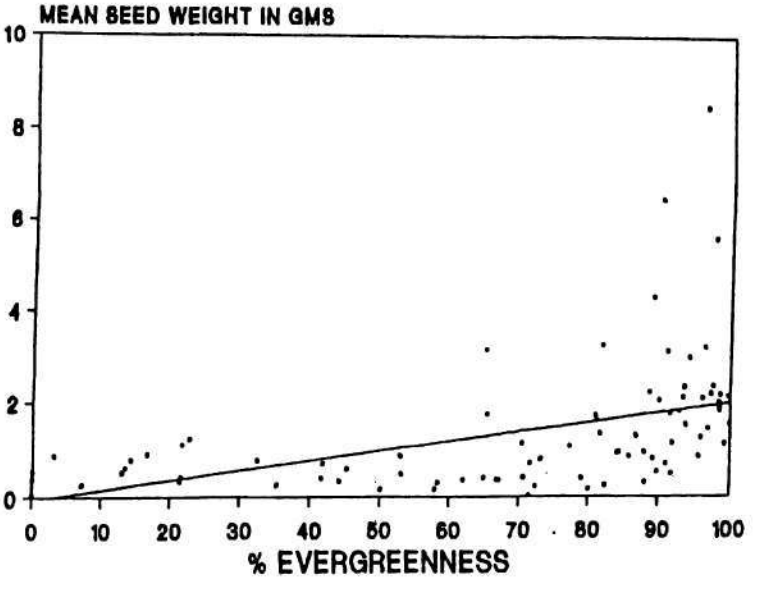


Figure 6. Correlation between evergreenness and coppicing character for tree population in 81 samples

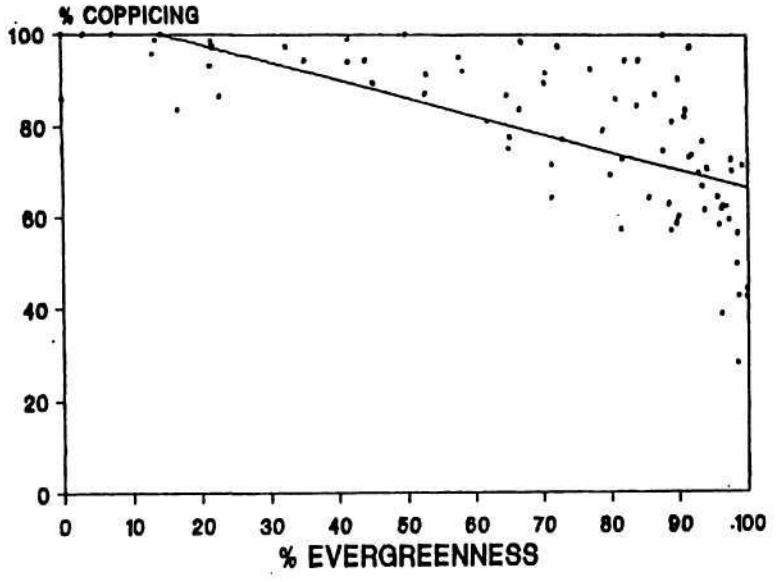


Figure 7. Age classes of *Terminalia paniculata*, a deciduous tree, in 25 one ha forest samples of Uttara Kannada. Note that high evergreen forests have only older trees.

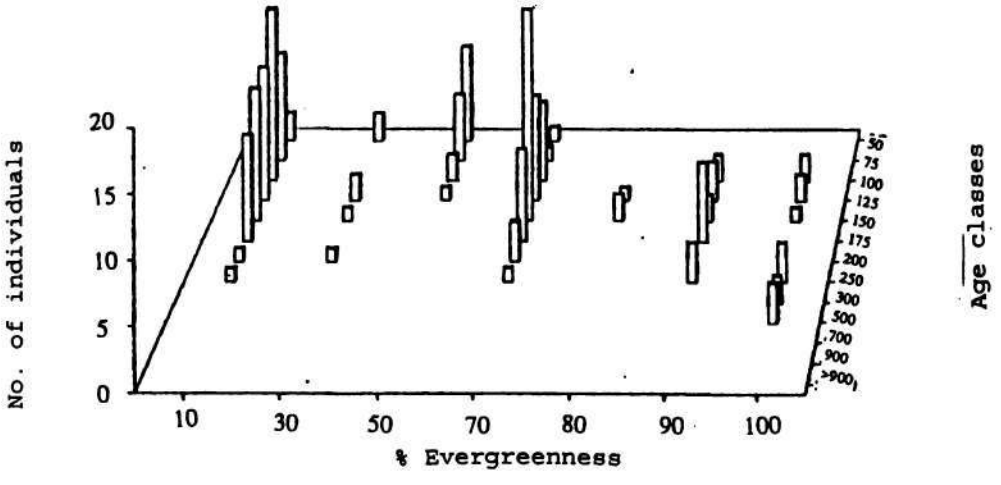
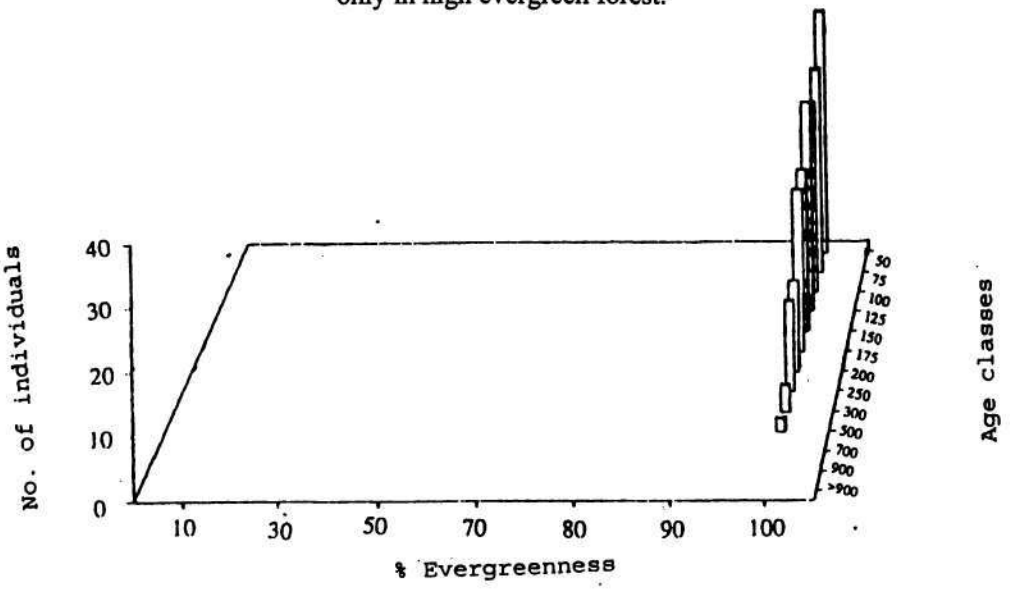


Figure 8. Age classes of *Dipterocarpus indicus*, an endemic evergreen tree of the Western Ghats in 25 one ha samples. Note that the species, in all ages, occur only in high evergreen forest.



References:

1. Myers, N. The Environmentalist, 1990, 10(4), pp. 273-295.
2. Gadgil, M., Curr. Sci., 1996, 70, 36-44.
3. Hladik, C. M., Linares, O. F., Hladik, A., Pagezy, H. and Semple A., in Tropical Forests, People and Food. Biocultural Interactions and Applications to Development (Eds Hladik, C.M., Hladik, A., Linares, O. F., Semple, H. and Harley, M.), MAB Vol. 13, UNESCO nad Parthenon, Paris, 1993.
4. Yen, D.E., in Foraging and Farming : the Evolution of Plant Exploitation (Eds Harris, D. R. and Hillman, G. C.), Unwin Hyman, London, 1989, pp. 55-75.
5. Groube, L., in Foraging and Farming : the Evolution of Plant Exploitation (Eds Harris, D.R. and Hillman, G.C.), Unwin Hyman, London, 1989, pp. 292-404.
6. Cooke, R. and Piperno, D., in Tropical Forests, People and Food - Biocultural Interactions and Applications to Development (Eds Hladik, C.M., Hladik, A., Linares, O. F., Semple, H. and Hadley, M.) MAB Vol. 13, UNESCO and Parthenon, Paris, 1993.
7. Kajale, M.D., in Foraging and Farming : the Evolution of Plant Exploitation (eds Harris, D.R. and Hillman, G.C.), Unwin Hyman, London, 1989, pp. 269-281.

8. Golson, J., in Sunda and Shul : Prehistoric Study in South east Asia, Melanesia and Australia (Eds Allen, J., Golson, J. and Jones, R.), Academic Press, London.

9. Rajendran, P., Prehistoric Cultures and Environment, Classical Publishing Co. New Delhi, 1989.

10. Unnikrishnan, V., Sacred Groves of North Kerala - an Eco-Folklore Study, (in Malayalam), Jeevarekha, Thrissur.

11. Abhishankar, K., (ed.) Gazetteer of Chikmagalur District, Government of Karnataka, Bangalore, 1975.

12. Abhishankar, K., (ed.) Gazetteer of Shimoga District, Government of Karnataka, Bangalore, 1981.

13. Sundara, A., in Perspectives in Dakshina Kannada and Kodagu, Mangalore University Deccennial Volume, 1991, pp. 41-63.

14. Sahu, B.P., From Hunters to Breeders, Anamika Prakashan, Delhi, 1988.

15. Alur, K.R., in Protohistric Cultures of the Tungabhadra Valley. A Report on Hallur Excavations (ed. Rao, M.S.N.), Dharwar, 1971, pp. 107-124.

16. Dhavalikar, M. K., in Archaeological Perspectives of India since Independence, Indian Archaeological Society, New Delhi, 1985, 51-54.

17. Sundara, A., Some aspects of the Neolithic sites in Malnad, Mysore State, QIMS VII LIX, Bangalore, 1969.

18. Shetty, B., Some Recent Archaeological Notices: Megalithic Relics in Dakshina Kannada - a Study. Archeology in Karnataka, DAM, Mysore, 1990.

19. Subbaya, K. Archaeology of Coorg, Geetha Book House, Mysore.

20. Murthy, M. L. K., Pre-Iron Age Agricultural Seetlements in South India : an ecological Perspective. Paper presented at Discussion Meeting of Ecological History of India 9-11 Feb. 1988. Centre for Ecological Sciencs, Indian Institute of Science, Bangalore.

21. Bhat, H.R.R., A paper on the Important Notices in Siddapur Tk., Uttara Kannada. Third annual Session of the Karnataka Ithihasa Academy at Gadag, 1989.

22. Caratini, M., Fontugne, M., Pascal, J. P., Tissot, C. and Bentelab, I., Curr. Sci., 1991, 61(9), 669-672.

23. Sukumar, R., Ramesh, R., Pant, R.K. and Rajagopalan, G., Nature, 1993, 364, 703-706.

24. Pascal, J. P., Explantory Booklet on the Forest Maps of South India, French Institute, Pondicherry, 1986.

25. Pascal, J. P., Wet Evergreen Forests of the Western Ghats of India : Ecology, Structure, Floristic Composition and Succession, French Institute, Pondicherry, 1988.

26. Gadgil, M. and Meher-Homji, V.M., Proceedings of the Indian academy of Sciences (Animal Science/Plant Science) Suppl., 1986, 165-180.

27. Chandran, M.D.S., Vegetational Changes in the Evergreen Forest Belt of Uttara Kannada District of Karnataka State, Ph.D. thesis, Karnatak University, Dharwad, 1993.

28. Ashton, P.S., Ecological Studies in the Mixed Dipterocarp Forests of Brunei State, Clarendon Press, Oxford, 1964.

29. Valdiya, K.S., Resonance, 1996, 1(5), 19-28.

30. Dixit, K.N., in Archaeological Perspectives of India since Independence, Indian Archaeological Society, New Delhi, 1985, pp. 55-61.

31. Sundara, A., Chalcolithic phase of the Upper Krishna Valley Studies in Indian History and Culture, P.B. Desai Felicitation Volume, Dharwad, 1971.

32. Sali, S.A., Daimabad, 1976-79, ASI, New Delhi, 1986.

33. Kamath, S.U., Gazetteer of India : Uttara Kannada, Government of Karnataka, Bangalore, 1985.

34. Honnappa, Venkatachalapaty, V.V. and Shareef, N.A., The Indian Geographical Journal, 52(1) 1977, 15-22.

35. Bourgeon, G., Explanatory Booklet to Reconnaissance Soil Map of Forest Area : Western Karnataka and Goa, French Institute, Pondicherry, 1989.

36. Mascarenhas, A., Paropakari, A. L., and Babu, P., Curr. Sci. 64 (9), 1993, 684-687.

37. Pascal, J.P., Vegetation Maps of South India, Karnataka Forest Department, Bangalore and French Institute, Pondicherry, 1982, 1984.

38. Ward, Lt. and Conner, Lt., Memoir of the Survey of the Travancore and Cochin States, Surveyor-General's Office, Madras, 1827.

39. Cleghorn, H., Forests and Gardens of South India, W.B.Allen and Co., London, 1861.

40. Bourdillon, T.F., Report on the Forests of Travancore, Travancore Government Press, 1893.

41. Buchanan, F.D.A. Journey from Madras through the Countries of Mysore, Canara and Malabar, vol 2., Higginbothams, Madras.

42. Gadgil, M., Berkes, F. and Folke, C., Ambio, 1993, 22 151-156.

43. Gadgil, M., in Conservation of the Indian Heritage (Eds. Allchin, B., Allchin, F.R. and Thapar, B.K.), Cosmo Publications, New Delhi, 1989.

44. Chandran, M.D.S. and Gadgil, M., in Geschichte der Kleinprivatwaldbesitzer Geschichte des Bauernwaldes, (ed. Brandl, H.), Forstliche Versuchs-und Forschungsanstalt, Freiburg, 1993, pp. 49-57.

45. Gadgil, M. and Vartak, V.D. Journal of Bombay Natural History Society, 1975, 72, 314-320.

46. Brandis, D. and Grant, L., Joint report no.33 dated 11th May, 1868, on the kans of the Sorab Taluka. Forest working Plans Office, Shimoga.

47. Krishnamoorthy, K., Myristica Swamps in the Evergreen Forests of Travancore; in Tropical Moist Evergreen Forest Symposium, Forest Research Institute, Dehra Dun, 1960.

48. Mohanan, M. and Henry, A.N., Flora of Thiruvenanthapuram, Kerala, Botanical Survey of India, Calcutta, 1994.

49. Troup, R.S., The Silviculture of Indian Trees, 3 vols., Clarendon Press, Oxford, 1921.

50. Chandran, M.D.S., (in press) Nature and the Orient: Essays on Environmental History of South and South East Asia (Eds. Grove, R., Damodaran, V. and Sanghvan, S), Oxford University Press, Oxford.

51. Gadgil, M. and Chandran, M.D.S., Environmental Impact of Forest Based Industries on the Evergreen Forests of Uttara Kannada, a case study (final report); Department of Ecology and Environment, Government of Karnataka, 1989.

52. Prabhakar, R. 1994. Resource Use, Culture and Ecological Change: A Case Study of the Nilgiri Hills of Southern India, Ph.D. thesis, CES, Indian Institute of Science, Bangalore, 1994.

53. Wingate, R.T., Settlement proposals of 16 villages of Kumta taluk; no. 210, Dec. 1888. Forest Settlement Office, Karwar.

54. Sukumar, R., Suresh, H.S. and Ramesh, R. Journal of Biogeopraphy, 1995 22, 533-536.

55. UNESCO., Tropical Forest Ecosystems: A State of Knowledge Report, UNESCO, Paris, 1978.

56. Garwood, N.C., in Ecology of Soil Seed Banks (Eds. Leck, M.A., Parker, V.T. and Simpson, R.L., Academic Press, California, pp. 149-209.

57. Waller, D.M., in Plant Reproductive Ecology, Patterns and Strategies, (Eds. Doust, J.L. and Doust, L.L), Oxford University Press, New York, pp. 203-227.

58. Foster, S.A. and Janson, C.H., Ecology, 1985, 66, 773-780.

59. Nicholson, D.I., Proc. Symp. on Humid Tropics Vegetation, UNESCO, 1965.

60. Rai, S.N. A series of Papers on Age Estimates in Forest Trees of the Western Ghats, published between 1978-1987.

61. Rai, S.N., Van Vigyan, 1982, 20, pp. 66-73.

62. Rai, S.N., Indian Forester, 1980, 106(12), pp. 856-864.

63. Rai, S.N., Journal of Tropical Forestry, 1987, 3(2):, pp. 160-169.

Herb Species Diversity Of Western Ghats

Harish R. Bhat & Ghate Utkarsh [1, 2]

1. Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.

2. Centre for Participatory Management of Biodiversity, c/o FRLHT, 50, MSH Layout, Anandnagar, Bangalore, 560 024.

Abstract

We sampled herb species diversity from 9 different vegetation types, both man-made and natural, from 15 sites scattered widely, using 516 quadrats of 1m x 1m size along 86 transects, 60m in length. Altogether, we encountered 48,000 individuals belonging to 396 species. The species richness was highest in the semi-evergreen forests (7.3 +_ 2.5, mean + s.d./ 50 individuals) while lowest in the deciduous forests. Grasslands harboured the most distinctive set of species on one hand, while the coconut and rubber cultivation the other extreme, as revealed by the ordination techniques. The grasslands harboured species with lowest average niche-width (1.00 + 0.04) while the coconut and rubber plantations the most (1.09+_ 0.03). The evergreen forest haboured herb species that were more abundant everywhere (mean dominance 7.84 +_ 1.58%) while the rocky and scrubby vegetation had species with low average dominance (5.18 +_ 0.85%). The grasslands, rocky and scrubby vegetation have the highest conservation value as they shelter species with low niche-width, relatively rare and occupy smaller area. The coconut and rubber plantation community have lowest conservation value due to large spatial extent, wide niched, dominant species. We propose this methodology to be appropriate for assesing biodiversity and conservation values.

Introduction

Biodiversity - the variety of plants and animals on earth - has emerged as a major focal subject of late, both due to rapid destruction of this natural heritage as well as its enormous economic potential as a resource for biotechnlogical developments (Gadgil 1996). Its measurement and monitoring is a great challenge due to the variety and complexity of issues involved, and the scientists are only beginning to address these issues (Hawksworth

1995). Three most important questions for designing conservation strategy for biodiversity could be (a) what to conserve (b) where to conserve (c) how to monitor the conservation status and efficacy? This paper primarily attempts to address the the first two questions as a background information for the third one.

Deciding on conservation priorities would essentially require information on rarity of species including their geographical dispersion. There could be several ways of defining rarity based on global geographic distribution, diversity of habitat preference, abundance, taxonomic uniqueness etc. (Daniels et al 1991). The assessment of rarity was traditionally conducted on the basis of known distribution of all species through floral and faunal regional checklists. This led to synthesis of the Red Data Books, containing information on endangered plants (Nayar ans Sastry 1987-90). The exhaustive listing of species -especially micro-organisms and lower invertebrates is an enoromous task and scientists seldom have a complete checklist of sorts of organisms from even 1ha plots in the biodiverse rainforests (Janzen and Hallwards 1994). It is estimated that the earth could be harbouring between 3 to 30 million species of organisms, of which, barely 1.5 million are catalogued despite the considerable efforts of the taxanomists for the last few centuries. The multitude of undescribed species are either not collected or not sorted or not identified taxonomically, due to inadequancy of trained manpower, financial resources, storage facilities etc. Most of these undescribed species belong to lower plant and animal groups like insects or fungi. Although some scientists have launched ambitious programmes to document all the biodiversity of the globe (Systematic Agenda 2000, 1994), its future is uncertain, as it would require enormous economic resources and skilled manpower.

It is therefore evident that the inventory of biodiversity through checklists which indicate geographical availability or new taxonomic description can serve only few specific purposes, such as identifying species potentially useful for biotechnological applications. Such an approach however seems to be inadequate for addressing questions related to assigning conservation priorities and monitoring resource status. This limitation arises due to unequal degree of inventorying across geographical regions or taxonomic groups as well as very little attempts made for collecting information of species abundance. Hence, we need alternative approachs, of which, two essential features are -

a) comparable sampling effort across various geographical regions

b) estimation of geographical distribution and population levels.

It is also clear that such conservation assessment will have to focus on organismic

groups that are easy to study such as angiosperms or vertebrates or some of the lower organisms. Such easier groups can be extensively studied in many places by wider research enthusiasts to understand general patterns. At a few localities more intensive studies on less known cryptic difficult groups can be conducted and their patterns can be used for extrapolation to wider scales.

It is with this rationale that we attempt here to develop a methodology for assessing the diversity levels, ecological attributes and conservation values of herb species of the the Western Ghats and the various habitat types these herbs occupy. We have resricted our analysis to only the field data. The information on species endemic to the Western Ghats could have been useful for instance as used in analysis by Daniels et al (1990). However, we have deferred using secondary information as it is largely lacking in case of lower plant and animal groups to which we wish to extend our methodology. The specific questions addressed here are:

a) whether different habitat i.e. vegetation types differ in their herb species diversity and abundance levels, if so how?

b) whether the different vegetation types differ in terms of geographical or community level rarity of species they contain ?

c)which are the vegetation types with high conservation value i.e. containing geographically restricted, less abundant species?

Methodology

Study Area

We have carried out these investigations along the Western Ghats tract, which is a mountain range some 1500 km long and 5-50 km wide, running parallel to the West Coast of India. It is one of the 18 biodiversity hotspots in the world, due to considerable levels of endemicity, especially amongst plants, reptiles, amphibians and butterflies as well as high human threat (Anon 1993). Indian Institute of Science has been actively networking with 20 colleges distributed allover the Western Ghats, for conducting biodiversity inventories and conservation evaluation (Gadgil 1996). The present work is based on herb communities sampled at 15 diferent localities in 9 different vegetation types scattered all along the Western Ghats in the states of Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu (Fig. 1. Table 1). The local colleges guided us to their study areas nearby and supported our sampling programme.

Vegetation Typology

For classifying vegetation, we have distinguished two domains- i) natural/ seminatural ii) manmade. This is not to say that the natural vegetation types are completely free of human influence or that manmade ones have no natural species. This nomenclature is only indicative of the relative degree of human intervention in shaping the elements. Our classification is compatible with and based on that of the UNESCO (Muller Dombois and Elleinberg. 1974) and other standard systems (Fosberg 1961.).

In the natural domain two categories are identified - forest and nonforest vegetation types. The forest category vegetation types have trees usually taller than 5 m, canopies of neighbouring trees often touch each other and the total tree canopy covers more than 60% of the ground. These can be classified into broad leaved evergreen, semievergreen and deciduous types of vegetation depending upon variation in tree heights and proportion of leaf shedding trees during summer.

The nonforest category types have between 30 to 60 % of the ground under canopy cover of the trees or woody vegetation are dominated by herbaceous vegetation. The scrub consists of trees 3-5 m tall, uneven canopy, crooked and entangled branches, stems often branching at the base, numerous branchlets, preponderance of thorny species etc. The thicket comprises of clumps of trees and shrubs shorter than 3 m and is more dwarf than the scrub. The grasslands differ from savannas in that the trees or woody plants are almost absent. This category also includes rocky, lateritic or sandy outcrops or barren areas where little plant life can flourish, that too only during monsoon.

In the manmade domain, the vegetation types from horticulture category can be differentiated into several types of fruit crops and other tree cash crops. Of these, arecanut, coconut, casuarina and rubber have been studied here. Amongst annual/ biannual crops, we have sampled paddy fields along bunds or after harvest, all -over the field.

Sampling Design

We sampled herb species along at least two line transects in each distinct vegetation type occurring within a locality. We encountered 9 such distinct vegetation types across 15 localities, though each type was not present in every locality. Table 1 explains the occurrence of vegetation types in various localities and the number of transects sampled. Each transect was 60 m long along which we enumerated all herb species and their individuals in six equidistant quardrats placed alternartively on both sides of the line measuring 1 x 1m (Fig,2). Species whose taxonomic identity could not be confirmed in the field were identified as morphospecies

or Operational Taxonomic Units (OTUS). Their taxonomic identity was ascertained later in the laboratory, using standard floristic literature (Cooke 1901 - 1908: Gamble 1919 - 1935) and referring to the Karnataka Flora Herbarium at the Centre for Taxonomic Studies, Indian Institute of Science, Bangalore (Saldhana and Nicolson 1978).

A total of 48,000 individuals belonging to 396 species of herbs were enumerated, from 396 quadrats along 86 transects spanning 9 vegetation types in 15 localities. Of these, over 95% could be assigned to species level identity, a few at the genus level and others as only OTUS. Using these data, we estinmated several ecological attributes of the species as well as sites they occupy as follows;

Species Composition

We subjected species transects abundance matrix to recriprocal averaging ordination technique (Ter Braak et al 1986) to assess differences in species composition of the 86 transects. This algorithm scores each transect and species such that their arrangement in the ascending or descending order of their scores reflects an ecological gradient, such as from dry to moist vegetation. Thus, if we reorganise the species-sites abundance matrix, most of the abundance values concentrate along one diagonal while the two opposite corners largely contain empty cells due to non - occurrence of those species in those sites. Of course, the scores, by themselves might not satisfactorily reflect the ecological differences between the species or the transects. However, it is suffice to assume that higher the rank difference between two species or two sites, greater is the difference in their ecological conditions.

We also seperately performed detrended correspondence analysis (DCA) on the species-sites abundance data (Ter Braak et al 1986), which provided a score for each site on 2 imaginary, mathematical axis. We consider here scores on only the first DCA axis. We then looked at the correlation between scores of all sites derived by DCA and reciproral averaging methods, to understand if these two methods of ordination assign very different weights to various sites.

Species Diversity

For assessing species level alpha diversity i. e., degree of species packing, we used a simple index viz. rarified species richness (i. e., raw count) per every 50 adjacent individuals. For, this was the least number of individuals in a transect amongst all the transects and hence, could be compared across all the 86 transects. We chose rarefaction procedure to ensure that the strength of individuals in the sampling units does not introduce much bias in the diversity estimates i. e. to ensure that some transects do not appear more speciose

simply because more individuals have been sampled along these transects than others. Maguran (1988) as well as Ludwig and Reynold (1988) in their classical Treatise on Ecological Diversity, have emphasised that rarified species richness is a simple, robust and useful index.

Species niche-width estimates:

Although niche has been variously defined in the ecological literature, objectively speaking it consists of geographical distribution, variety of habitat types occupied and methods of resource harvesting e. g. food (ibid). It is well beyond ordinary experimental capacities to generate field data on resource usage strategies and habitat occupancy of all the species. Hence, we did not use the data on absolute geographical distribution of each species. Instead, we calculated the niche width of each species in terms of distribution and habitat occupancy based on our data alone (Utkarsh et al 1997). Intuitively, a wide niche species would be the one geographically more widely distributed and/or occupying very different kinds of habitats. Both these factors are reflected in dissimilarity (turnover) of species composition between all transects occupied by a species. Thus dissimilarity values for all the pair-wise combinations of transects was calculated. Of all these relevent pairs for each species were used for calculating, the mean chord distance was used as an estimator of species composition dissimilarity. The chord distance is given as:

$$djk = v - 2\left[1 - \frac{(E\ Xij * Xik)}{(v - EXij2 * EXik2)}\right]$$

where djk is the chord distance between transects j and k, Xij and Xik are abundance values of species X in the transects j and k respectively.

The mean dissimilarity was found to be independent of frequency of species, especially in large datasets from varied environments (ibid., Gadgil et al 1996). Thus species occurring in few sites or more sites may have same niche width. Intuitively a widespread/more frequent species has higher nichewidth. For, it cannot become widespread without having greater capacity or ways to harness the resources, than species with restricted occurrence. To account for this fact we added proportion of transects occupied to the nichewidth calculated above. This is corrected nichewidth i. e. adjusted for frequency of occurrence.

Individual species nichewidth can be interpreted in the light of their frequency or wider geographical distribution. Mean nichewidth of all species in a site can be considered as a measure of specialization i. e. on kind or rarity of constituent species. Wider mean nichewidth of species in a transect suggests that it contains more widespread species which also have

wider habitat preference. Lower is the mean nchewidth of species in a transect, narrower is the geographical distribution and habitat preference of its constituent species.

Species dominance

One pertinent question in this regard is to assess whether different communities differ in their constituent species having a greater or smaller tendency to dominate the vegetation wherever they occur. The traditional community dominance index like the Simpson's index (Maguran 1988) measures the proportional dominance of all the species at a given site. It does neither quantify how far dominant a given species is on all the sites nor does it measure the tendency of all the species at a given site.

The dominance of each species in each transect was calculated as

$$d_i = n_i/N$$

where di is dominance of species i, ni, is its total number of individuals, N is total number of individuals in the transect. The mean dominance of a species occurring in X transects was estimated as

$$d = \frac{d_i + \ldots\ldots\ldots\ldots\ldots\ldots + d_x}{x}$$

wherein dis mean dominance, di to dx are its dominance values from transect one through x.

The average of this mean dominance of all the species occurring in a transect was then calculated as

$$D = \frac{d_1 + d_2 + \ldots\ldots\ldots\ldots\ldots\ldots + d_n}{n}$$

where D is the mean of the mean species dominance of a transects, d1 to dn are its mean nichewidth of species one to n.

Conservation Values

If we want to follow a developmental path that minimises the harm to biodiversity we should assign conservation values to its components so that more valuable elements can be preserved at the cost of the less valuable ones. The ongoing subjugation of biodiversity values to the irrational development process could be due to the lack of an appropriate evaluation

methodology (Pramod et al 1997b). Developing sound evaluation techniques would provide a better understanding of the trade-offs between environmental protection and economic development. In this context, we propose that the types with lower mean species nichewidth have higher conservation value as they tend to shelter species with narrower geographical distribution and habitat preference. Similarly, the types with low mean dominance have higher conservation rank as the shelter rare species i. e. those with small local population sizes.

Limitations of the Study

Herb sampling could not be conducted in all the seasons at all the places. This has lead to inadequate representation of ephemeral species that bloom immediately after first monsoon showers and wither soon. Further, different localities in different phases of monsoon might harp introduced some bias in the interpretation. However, we believe that the analytical approach developed here is a robust one and can be applied in future to better data sets, for not only herb but most communities of plant and animal taxonomic groups.

Results

Species composition

Fig. 3 shows that according to both the ordination techniques the grasslands harboured most distinctive set of species on one hand while monoculture plantations like coconut and rubber sheltered herb communites that differ the most from the grasslands. Other vegetations types have species composition transitional between these two extremes. Arecanut, Acacia and Casuarina monoculture tree plantations harbour species composition similar to that of the Coconut and Rubber plantation. The scores of vegetation types desired using both these ordination techniques - reciprocal averaging and detrended correspondence analysis - are tightly correlated. Table 2 represents the species-vegetation types abundance matrix for 50 most important species arranged in the order of reciprocal averaging scores of the species and vegetation type. The dominance (i.e. mean abundance per transect) of these 50 most important species is so pronounced that they together contribute between 40 to 90% of all individuals in the transects.

Species Diversity

Fig. 4 shows that the density of individuals and species richness across vegetation types are neither correlated, nor reflect any human impact gradient. Thus, while all the three forest types shelter herbs at lowest density, the diversity of semi-evergreen forests is the highest amongst all vegetation types while that of the deciduous forest is the lowest. The other natural vegetation type - grassland - has moderate diversity but highest density of individuals while rocky thickets and scrub harbour least diverse but dense herb communites. Paddy

fields, a manmade vegetation type, harbours most diverse herb communities that also have high density levels. All monoculture plantations like Coconut, Rubber, Arecanut, acacia and Casuarina have low to moderate levels of diversity and moderate to high levels of individuals density.

Species Frequency and Abundance

Fig. 5 depicts the tight correlation between frequency of species and its abundance ($r = p<$) As expected, species occurring in fewer transects differ widely in abundance levels.

Table 3 lists the most frequent and abundant species.

Species niche-width and dominance

Fig. 6 shows the lack of correlation between frequency of species and the average chord distance between transects it occupies, calculated on the basis of species composition. The figure shows that the species occurring in larger number of transects necessarily have wide variation in its associate species, which presumably reflects wide variety of environmental conditions. On the other hand, the species occurring in fewer transects can either occur in very similar communities or very different communities i. e. these less frequent species can have very narrow or very wide environmental preference. Since the frequency of a species and the dissimilarity between communities in inhabits are not correlated, adding these two values as an index of niche width is an appropriate methodological step. Table 4 lists the most wide niched species and Table 2 depicts their distribution across vegetation types.

Fig 7 reveals that the species niche-width and its average dominance are not correlated. Thus, a closer look at Table 2 enables us to identify species varying widely along these two axis. Some of the species can be classified into atleast the following four categories-

a) Wide niched, often abundant - *Certococcum patens*
Eragrostis unioloides etc.

b) Wide niched, often rare - *Oldenlandia auricularia*
Ischaemum indicum
Phyllanthus urinaria etc.

c) Narrow niched often rare - *Aneilema pauciforum*
Rottobollia divergens etc.

d) Narrow niched, locally abundant - *Cyathula prostata*,
Curcuma oligantha etc.

Fig 8 demonstrates the weak correlation between species niche width and dominance. Table 2 shows that the grasslands harbour very narrow niched, less dominant species, closely followed by rocky and scrubby vegetation. The evergreen forests shelter narrow niched but locally abundant species while the monoculture tree plantations shelter very wide niched and less dominent species.

Conservation Values

Fig 9 and Table 2 show that the mean conservation values of transects belonging to various types, calculated separately on the basis of niche width and average dominance of constituent species, and are not correlated. This is expected as niche width and dominance of species are uncorrelated. Fig 10 shows that there is no correlation between species diversity and conservation value of the vegetation types.

Discussion

The sequence of ordination assigns the evergreen and semievergreen forests scores in between the man made vegetation types and the other natural types. This might be due to the fact that these two forest types have very limited flora of their own, and mostly shelter species common with other types and thus present a continum of species composition. Further, there seem to be no clear cut distinction between the natural and manmade vegetation types in terms of species density and diversity.

The right correlation between species frequency and abundance is intutively obvious, but the regression coefficients could prove usefull. For, these allow one to just note the presence or absence of species in many areas to generate much more information than diverting these efforts to estimate its abundance in fewer places. In fact, abundance measurements at a few places accompanied by survey of their presence-absence at many places, can become very efficient and intelligent strategy of inventorying and perhaps, also monitoring species populations.

The lack of correlation between species frequency and niche-width as judged by diversity of associate species, suggests that even geographically restricted species can have very wide habitat preference or species restricted to certain habitat type might inhabit wider geographical areas. Similarly, the lack of correlation between niche-width and dominance could be the result of various factors including competition. This suggests that competitive abilities of a species to colonize wider area and establish dominant populations in those areas, may differ widely.

Grasslands harbour the most distinctive set of species, species which tend to be dominant but have a low specialised, narrow niche. The Coconut and Rubber plantations on the other hand, do not harbour such narrow niched species, but shelther species which are common to other vegetation types as well as are quite dominat.

Evergreen forests harbour herb species which are most dominant wherever they occur, while the rocky and scrubby vegetation shelther species which are least dominant. This may be the result of the drier conditions prevailing in the scrubby vegetation and poor soil content in case of rocky vegetation. Hence, under such unfavourable conditions, only the least dominat species of all other types are left behind. Most of the species occuring in Coconut, Rubber and Acacia plantations are commonly found in other vegetation types also. There are very few species restricted to any one particular vegetation types except perhaps the evergreen forests which harbours a number of low nichewidth species belonging to genera like *Elatostemma, Alpinia, Curcuma, Zingiber* and *Apama.*

Grasslands, rocky and scruby vegetation had highest conservation values, due to low niche-width and less dominant species of grasses like *Chrysopogon, Cymbopogon,* and *Arundinella.* Herbs belonging to genera such as *Exacum, Agenatia, Erigeron, Lepidagathis* and *Pimpinella* also prefer the grasslands, rocky and scruby vegetations.

This research assumes significance in the context of debate regarding effects of monoculture tree plantations on biodiversity. The land with few trees is generally considered degraded and is planted with monocultures of Acacia or Casurarina trees to restore its ecological values. Our results show that such so-called degraded lands, especially the montane grasslands, have high conservation value as they shelter rarer, specialised herb species while the herb species communities in the tree plantation areas harbour herb species with lowest conservation priority.

This pattern may or may not repeat when studies on other plant and animal groups are taken up. We also do not suggest that the barren areas in dry zone or urban area having profuse growth of weedy species have high conservation value. All we wish to do is to reiterate the view of Sukumar *et al* who emphasise that montane grasslands have their characteristic flora, worthy of conservation, and it should not be improverished by well intentioned but ill affecting the plantations. Our purpose is not to suggest that all new monoculture tree plantations be stopped. Instead, we should objectively distinguish between grasslands with high conservation values that need to be maintained as such and those with species with low conservation value. The latter kind of areas can be converted to tree monocultures on a priority basis.

Acknowledgements

We thank Prof. Madhav Gadgil for his guidance and encouragement. We are indebted to all the members of the Western Ghats Biodiversity Network for all the support. Guidance from Dr. K. G. Bhat, Dr. P. K. Rajgopal, Father C. J. Saldanha was most useful Dr. Arvinda Hebbar kindly introduced the senior author to existing worlds of biological research. Dr. N. V. Joshi provided all the software programmes and useful ideas. This work was supported by the grants from Ministry for Environment and Forests, Government of India and PEW foundation, U. S. A.

Table 1: Environmental Attributes of various study localities and distribution of herb sampling transects across study localities and vegetation types.

Abbreviations used: VEG-TYPE - vegetation type; VEG-NO - vegetation type serial number along human impact gradient LATI. - latitude degree north; ALTI. - altitude m above mean sea level; RAIN - average annual rainfall mm; RN_SL - length of the rainy season in months (rains > 75mm/ month).

ac - acacia and casurina, forestry, tree plantations; ar - areca orchards; cr - coconut and rubber orchards; p - paddy fields; g -grasslands; rts - rocks, thickets, scrub; dm - dry and moist deciduous forests; se - semievergreen forests; eg - evergreen forests.

Vcode	No.	VEG_TYPE: SITE/VEG_NO	LATI deg. N	ALTI m	RAIN mm/a	RN_SL mth	ac	ar	cr	p	g	rts	dm	se	eg	TOT
ph	1	Phansad	18.5	250	3000	4.7	-	-	-	3	2	-	-	1	-	6
ky	2	Koyna	17.5	800	6000	4.7	-	-	-	3	-	-	-	-	-	3
dj	3	Dajipur	17.5	600	2500	6	-	-	-	-	2	-	-	-	-	2
sd	4	Siddapura	14	600	2500	6	1	-	-	-	-	2	-	2	-	5
ac	5	Bhadravati	14	800	2500	6.25	2	-	-	4	3	-	2	-	2	13
sn	6	Sringeri	13.5	1000	6000	6.5	2	-	-	1	2	2	1	-	2	10
up	8	Perdoor	13.3	200	6000	6.5	-	-	-	-	-	1	-	1	-	2
kk	9	Karkala	12.8	300	5500	6.5	2	4	2	6	-	-	-	-	1	15
su	10	Sullia	12.8	300	5500	6.5	-	2	-	2	-	1	-	3	-	8
ub	11	Upper Bhavani	11.5	2000	4000	8	1	-	-	-	4	-	-	-	-	5
cc	12	Calicut	11.5	800	5000	7.3	-	2	1	-	-	-	-	-	2	5
mu	13	Mundur	11	600	3000	7.5	-	-	2	-	-	-	-	-	-	2
pk	14	Palakkad	11	150	3000	7.5	-	-	-	2	-	-	-	-	-	2
sd	15	Sadragiri	9.5	600	800	4	-	-	-	-	-	2	2	-	-	4
tv	16	Trivandrum	8.5	500	2000	8	-	-	1	-	3	-	-	-	-	4
		TOT TNO(17)					8	8	6	21	16	8	5	7	7	86

Table 2: Reciprocal averaging depicting 50 most important species and their average density of individuals in the nine vegetation types.

Abbreviations used: IND - individuals; SPP - species; TPN - vegetation type number: TYPE - vegetation type; TOT - total number of individuals per transect of all 435 species; RAV - reciprocal averaging score, DNS - Total density; T50 - total no. of individuals of these 50 most important species; ac - acacia, casurina; ar - arecanut, cr - coconut, rubber; p - paddyfields; g - grasslands; rts - rocky, thickets, scrub; drm - dry and moist deciduous forest; se -semievergreen forests; eg - evergreen forests.

		IND	107	262	381	134	140	361	270	409	474	
		SPP	15	31	30	14	22	38	24	25	29	
		TPN	7	5	6	9	8	4	1	3	2	
		TYPE	dm	q	r.t.s	e	se	p	ac	cr	ar	DNS
FAMILY	SPECIES	RAV	0	38	49	51	55	70	82	93	100	
Passifloraceae	*Adinia hondala*	0	5	-	-	-	-	-	-	-	-	5
Acanthaceae	*Carvia callosa*	12.1	38	4	8	-	-	1	-	-	-	51
Graminae	*Cymbopogon martini*	32.3	4	9	-	-	-	2	-	-	-	15
Zingiberaceae	*Curcuma oligantha*	36.2	37	10	14	-	34	2	5	2	1	105
Fabaceae	*Gessaspis tenella*	38.1	-	11	-	-	-	-	-	-	-	11
Cyperaceae	*Pyoreus latispicatus*	38.1	-	30	-	-	-	-	-	-	-	30
Graminae	*Heteropogon contortus*	43.2	-	19	16	-	-	-	-	-	-	35
Commelinaceae	*Aneilema pauciflorum*	43.3	1	5	3	-	-	-	-	1	-	10
Graminae	*Rottboellia divergens*	44.8	2	2	6	-	-	1	-	1	-	12
Cyperaceae	*Fimbriostylis dichotoma*	45.5	4	27	6	-	1	5	6	-	-	49
Rubiaceae	*Mitracarpus verticelletus*	46.2	-	9		-	2	- 1	1	-	-	13
Asteraceae	*Blumea membranacea*	48.1	-	7	4	-	1	1	1	-	-	14
Cyperaceae	*Chrysopogon hackeli*	49.1	-	8	-	-	-	4	-	-	-	12
Fabaceae	*Zornia diphylla*	50.7	-	3	45	-	-	5	-	-	-	53
Compositae	*Blumea lacera*	51.1	-	5	63	-	11	5	1	-	-	85
Rhamnaceae	*Ventilago bombaiensis*	51.9	-	-	-	4	-	-	-	-	-	4
Graminae	*Certococcum oxyphylum*	54.2	-	-	-	45	5	3	-	-	1	54
Dipterocarpaceae	*Hopea parviflora*	55.5	-	-	-	-	4	-	-	-	-	4
Graminae	*Cynodon dactylon*	56.3	1	5	11	30	-	12	-	-	4	63
Cyperaceae	*Cyperus rotundus*	56.3	-	8	-	-	1	10	-	-	-	19

Gramineae	*Themeda triandra*	57	-	13	1	-	-	18	-	-	-	32
Fabaceae	*Desmodium triflorum*	58.7	1	6	32	-	7	15	2	4	3	70
Gramineae	*Eragrostis unioloides*	59.3	-	25	15	27	9	20	20		- 5	121
Rubiaceae	*Oldenlandia auricularia*	64.1	-	3	49	-	2	10	1	7	14	86
Gramineae	*Ischaemum indicum*	64.7	-	12	3	4	1	22	4	6	1	53
Asteraceae	*Elephantopus scaber*	66.4	-	-	34	-	4	4	4	18	1	65
Asteraceae	*Eupatorium odoratum*	68.4	8	2	1	3	2	25	27	7	2	77
Graminae	*Oryza sativa*	69.1	-	3	-	-	-	47	-	-	-	50
Balsaminaceae	*Impatiens kleinli*	72.2	-	2	6	-	8	2	22	1	3	44
Acanthaceae	*Asystasia chelonoides*	74.1	1	-	1	-	-	1	-	1	3	7
Acanthaceae	*Nelsonia campestris*	75.6	-	1	7	1	0	11	-	21	3	53
Graminae	*Oplimenus compositus*	75.7	2	2	-	1	1	-	-	13	1	20
Malvaceae	*Sida rhombifolia*	77.1	-	-	4	-	-	2	6	1	3	16
Mimosoideae	*Mimosa pudica*	79.1	-	-	25	-	-	9	9	19	22	84
Apiaceae	*Centella alba*	79.4	-	-	-	4	-	26	-	-	15	45
Acanthaceae	*Justicia simplex*	79.4	-	10	1	-	3	5	35	6	16	76
Graminae	*Panicum notatum*	80.1	-	-	4	1	-	-	1	-	7	13
Euphorbiaceae	*Phyllanthus urinaria*	80.5	-	-	2	-	2	1	2	1	5	13
Fabaceae	*Abrus precatorius*	81.9	-	-	-	-	1	-	31	-	-	32
Graminae	*Paspalum compactum*	83.6	-	-	-	1	-	20	-	-	16	37
Pteridophyte	*Selaginella tenera*	85.4	-	-	1	6	2	3	-	6	18	36
Graminae	*Certococcum patens*	85.5	1	14	15	5	28	13	53	183	61	373
Compositae	*Ageratum conyzoides*	86.5	-	-	-	-	4	15	1	6	21	47
Graminae	*Opilsmenus burmari*	90.4	-	5	-	-	-	-	-	37	10	52
Graminae	*Panicum notatum*	92.1	1	-	2	-	-	16	3	-	59	81
Menispermaceae	*Cyclea peltata*	92.2	-	-	-	-	-	1	-	9	-	10
Asteraceae	*Synedrella nodiflora*	92.3	-	1	1	-	-	2	9	4	24	41
Graminae	*Digitaria bicornis*	92.7	1	1	1	-	-	7	11	41	43	105
Graminae	*Isachne globosa*	93.6	-	-	-	-	-	14	15	2	62	93
Amarantaceae	*Cyathula prostrata*	100	-	-	-	-	-	-	-	12	50	62
		T50	108	361	438	134	141	370	307	407	474	
		T50%	55	41	47	66	62	69	66	90	80	
		TOTA	197	883	931	202	230	540	465	454	593	

Table 3: Values of various environmental and community - ecological parameters for various vegetation types.

Abbreviations used: avg - average; std - standard deviation; LatN - Latitude degree north; RAIN - rainfall mm per annum; R_S - length of rainy season in months (rainfall >75mm/ month); Alt - altitude in m above mean sea level; DCA - 1 - detrended correspondence analysis; SPRM - mean species richness/ 50 individuals; mnc - mean nichewidth of constituent species; cv - conservation value assigned on the basis of cv_n) nichewidth and cv_d domnance; cv_t - conservation values derived on the basis of nichewidth and dominance united.

TYPE NO	TNO n	VEGETATION TYPE		Lat N	RAIN	R_S	Alt	DCA-1	SPRm	rav mnc	cv_n%	cv_d%	cv-t%	
1	8	ac	avg	13.4	4125	6.3	625	350	-0.49	6.5	84.2	1.08	6.12	24	48	69
			std	0.4	1635	0.2	268	257	0.24	3.7	5.7	0.03	0.89	11	25	35
2	8	Arecanut	avg	12.4	5250	6.7	375	580	-0.54	6.1	85.5	1.07	5.66	27	62	89
		Orchards	std	0.5	250	0.3	13	157	0.07	3.7	1.5	0.02	0.47	6	11	16
3	6	Coconut, Rubber	avg	11.4	4333	7.2	325	446	-0.57	5.3	86.6	1.09	5.70	19	62	81
		Orchards	std	1.4	1344	0.5	135	237	0.07	2.3	1.0	0.03	0.63	9	15	24
4	21	Paddyfields	avg	14.3	4205	6.0	445	491	0.29	7.2	78.4	1.05	5.92	33	59	92
			std	2.5	1493	0.9	269	183	0.24	3.8	5.7	0.03	0.97	11	22	22
5	16	Grasslands	avg	13.3	3625	6.5	684	602	0.31	6.5	62.4	1.00	5.72	54	64	118
			std	3.2	1474	1.2	577	301	0.43	3.1	11.8	0.04	1.07	16	26	37
6	8	Rocks, Scrub,	avg	12.5	3263	5.7	583	528	-0.15	5.4	75.5	1.03	5.18	41	79	120
		Thickets	std	1.8	1996	1.0	334	313	0.25	3.0	6.0	0.01	0.81	5	29	31
7	5	Dry and Moist	avg	12.5	3000	6.8	540	159	0.06	5.0	70.6	1.06	6.75	28	40	68
		Deciduous Forests	std	1.2	1517	0.6	387	93	0.47	1.3	12.2	0.02	0.82	6	14	20
8	7	Semievergreen	avg	14.7	4929	5.9	450	209	-0.33	7.3	80.9	1.03	6.94	41	43	84
		Forests	std	2.3	863	0.7	198	116	0.08	2.5	1.8	0.06	1.78	22	30	23
9	7	Evergreen	avg	12.8	4257	6.7	757	185	-0.47	7.0	84.5	1.03	7.84	44	26	70
		Forests	std	0.8	1487	0.4	333	148	0.26	1.6	7.5	0.07	1.58	31	21	24

Table 4: Most important 50 species and their distribution parameters.

Abbreviations used: FR -frequency i.e. no. of transects inhabited; ABD - abundance i.e. total no. of individuals recorded, NCH - nichewidth i.e. mean species chord dissimilarity between transects occupied plus proportion of total transects occupied; DOM - average of dominance values for all transects inhabited; Rank ABD, NCH, DOM - rank in the descending order w.r.t. abundance, niche, dominance.

Sr. No.	FAMILY	SPECIES	FRQ	NCH	ABD	DOM
1	Graminae	*Certococcum patens*	40	2877	1.35	14.2
2	Asteraceae	*Eupatorium odoratum*	32	911	1.28	8.8
3	Zingiberaceae	*Curcuma oligantha*	31	793	1.26	12.1
4	Rubiaceae	*Oldenlandia auricularia*	30	819	1.27	4.9
5	Fabaceae	*Desmodium triflorum*	27	791	1.22	5.5
6	Graminae	*Ischaemum indicum*	24	780	1.19	6.2
7	Balsaminaceae	*Impatiens kleinii*	24	374	1.15	4.8
8	Graminae	*Cynodon dactylon*	22	669	1.18	7.0
9	Cyperaceae	*Fimbristylis dichotoma*	22	648	1.19	4.2
10	Graminae	*Eragrostis unioloides*	21	1388	1.15	9.8
11	Graminae	*Digitaria bicornis*	21	840	1.13	10.2
12	Mimosoideae	*Mimosa pudica*	21	745	1.14	7.3
13	Compositae	*Ageratum conyzoides*	21	553	1.12	4.8
14	Acanthaceae	*Justicia simplex*	20	745	1.07	6.1
15	Asteraceae	*Elephantopus scaber*	20	532	1.09	4.8
16	Apiaceae	*Centella alba*	19	698	1.12	7.4
17	Asteraceae	*Synedrella nodiflora*	17	327	1.07	4.2
18	Euphorbiaceae	*Phyllanthus urinaria*	17	120	1.03	1.2
19	Graminae	*Ischane globosa*	16	927	1.08	9.4
20	Compositae	*Blumea lacera*	16	774	1.13	9.5
21	Pteridophyte	*Selaginella tenera*	16	309	1.05	3.6
22	Malvaceae	*Sida rhombifolia*	15	165	1.02	2.3

23	Menispermaceae	*Cyclea peltat*	15	79	1.11	2.0
24	Graminae	*Oryza sativa*	14	1031	1.03	15.7
25	Graminae	*Panicum notatum*	14	855	1.00	13.4
26	Graminae	*Paspalum compactum*	14	564	1.09	9.4
27	Acanthaceae	*Nelsonia campestris*	14	510	1.07	9.6
28	Graminae	*Oplismenus compositus*	14	149	1.11	5.9
29	Cyperaceae	*Cyperus rotundus*	13	334	1.04	5.4
31	Asteraceae	*Blumea membranacea*	13	178	1.02	2.6
32	Graminae	*Panicum notatum*	13	120	1.06	2.6
33	Comelinaceae	*Aneliema pauciflorum*	13	103	1.09	1.9
34	Acanthaceae	*Asystasia chelonoides*	13	70	1.04	1.7
35	Amarantaceae	*Cyathula prostrata*	12	479	1.02	7.6
39	Graminae	*Rottboellia divergens*	12	108	1.08	2.8
42	Graminae	*Themeda triandra*	11	582	1.05	10.8
43	Graminae	*Certococcum oxyphyllum*	11	430	1.02	21.7
48	Graminae	*Heteropogon contortus*	10	440	1.01	11.5
63	Graminae	*Oplismenus burmani*	8	379	0.92	13.4
77	Fabaceae	*Zornia diphylla*	7	507	0.92	8.7
78	Acanthaceae	*Carvia callosa*	7	341	0.95	16.6
90	Graminae	*Cymbopogon martini*	6	204	0.97	14.7
107	Cyperaceae	*Chrysopogon hackeli*	5	200	0.96	9.8
121	Cyperaceae	*Pycreus latispicatus*	4	477	0.81	13.2
123	Rubiaceae	*Mitracarpus verticelletus*	4	176	1.01	10.7
134	Rhamnaceae	*Ventilago bombaiensis*	4	34	0.95	26.5
138	Fabaceae	*Abrus precatorius*	3	255	0.99	15.3
151	Dipterocarpaceae	*Hopea parviflora*	3	28	0.81	14.8
158	Fabaceae	*Geissaspis tenella*	2	180	0.77	10.4
169	Passifloraceae	*Adinia hondala*	2	28	0.98	10.4

Figure 1 : Study sites of the Western Ghats Biodiversity Network ..... in relation to the distribution of vegetation types. Open circles refer to the headquarters of the member institution, filled circles to the study sites. The letters L. M and H in brackets following the vegetation type refer to low (0-600m), medium (600-1200 m) and high (above 1200 m) elevation zones.

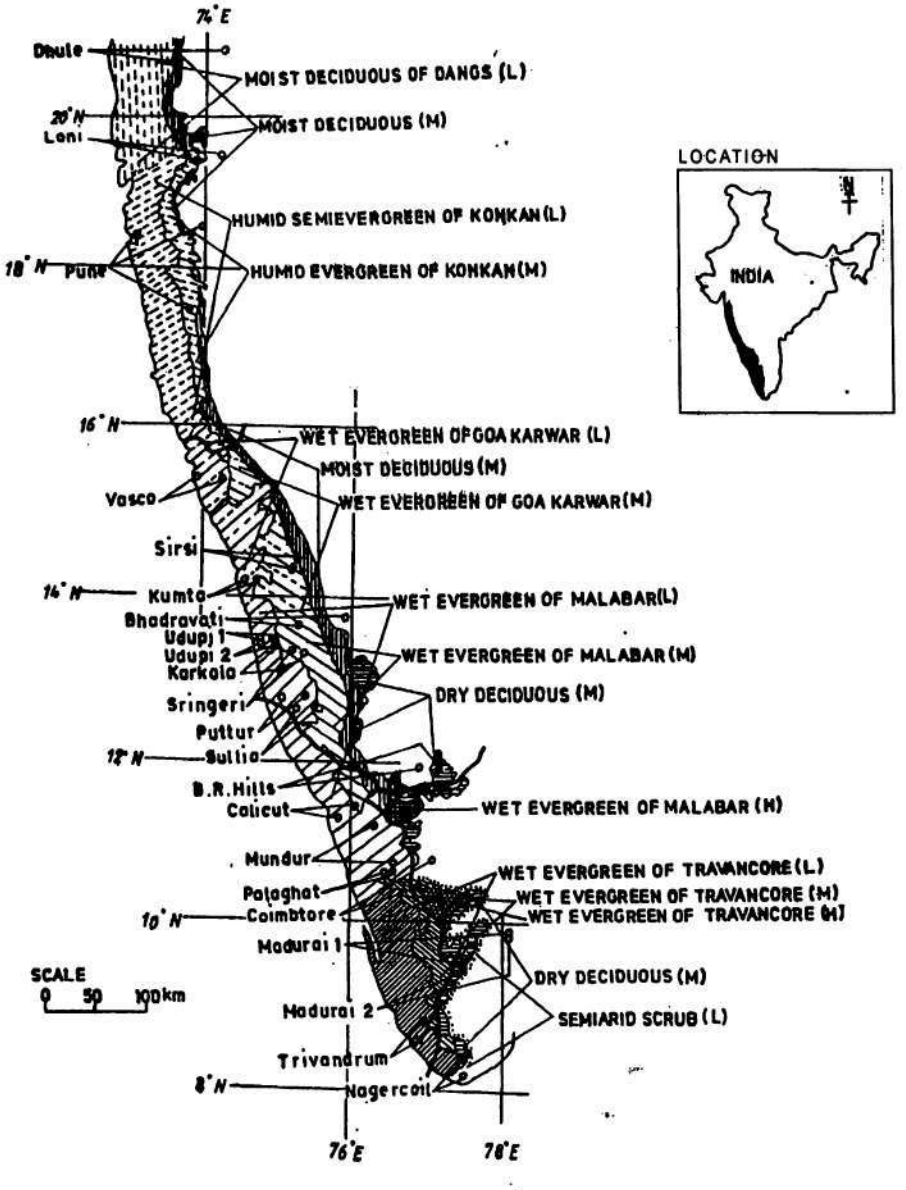


Figure 2 : The diagram showing layout of a typical transect.

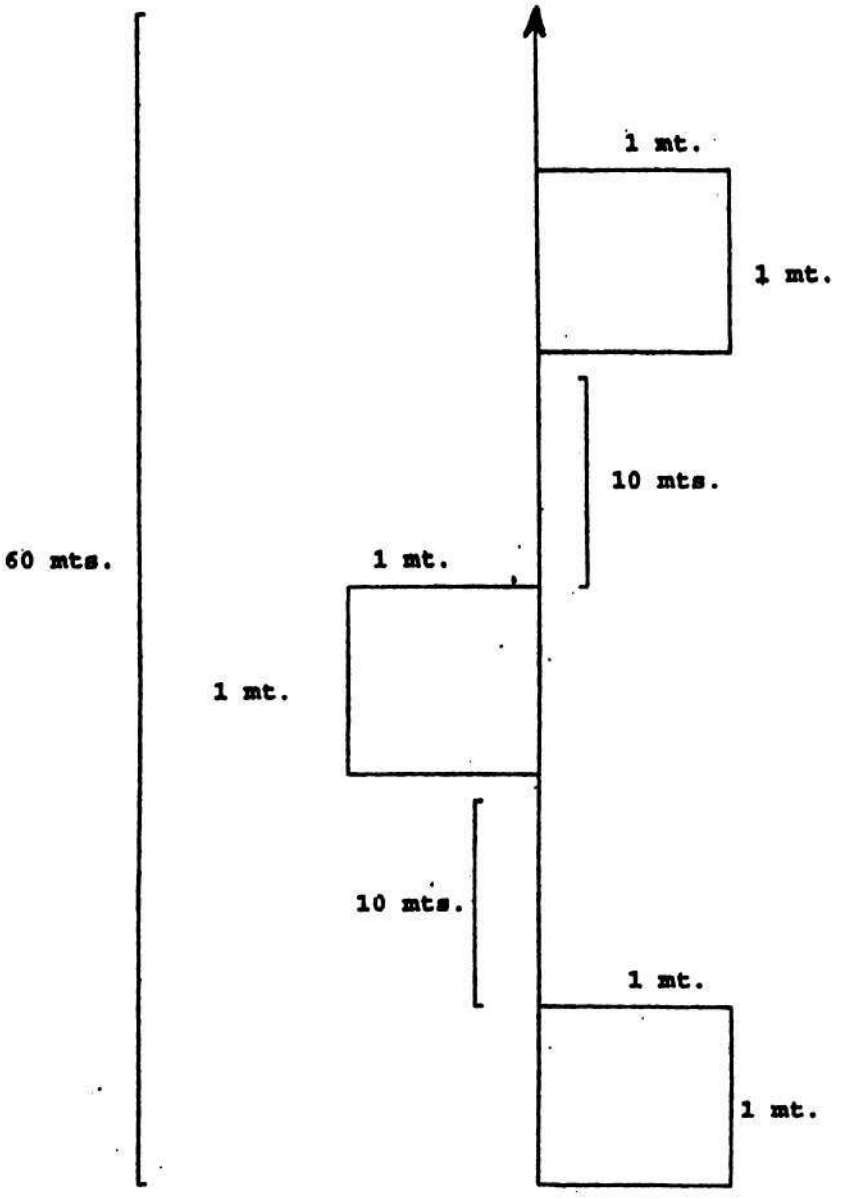


Figure 3 : The tight correlation between the site scores by reciprocal averaging and axis I (RAV) and the detrended correspondence analysis (DCA) axis I at the level of vegetation types.

Note: There is strong correlation between the ordination scores of vegetation types generated by by two different methods, indicating that the results may not be sensitive to the ordination technique used. The graph shows that while all the monculture tree plantiations and orchards harbour similar common kind of herb species composition one hand the natural habitats like the deciduous forests and grasslands harbour very different set of distinctive, restricted species.

Abbrevations used: ac - acacia casurina plantations, ar - arecanut orchards, cr - coconut, rubber orchards, p - paddy field, g - grasslands, rts - rocks, thrickets, scrubs dm - dry moist deciduous forests, se - semi evergreen forests, e - evergreen forests.

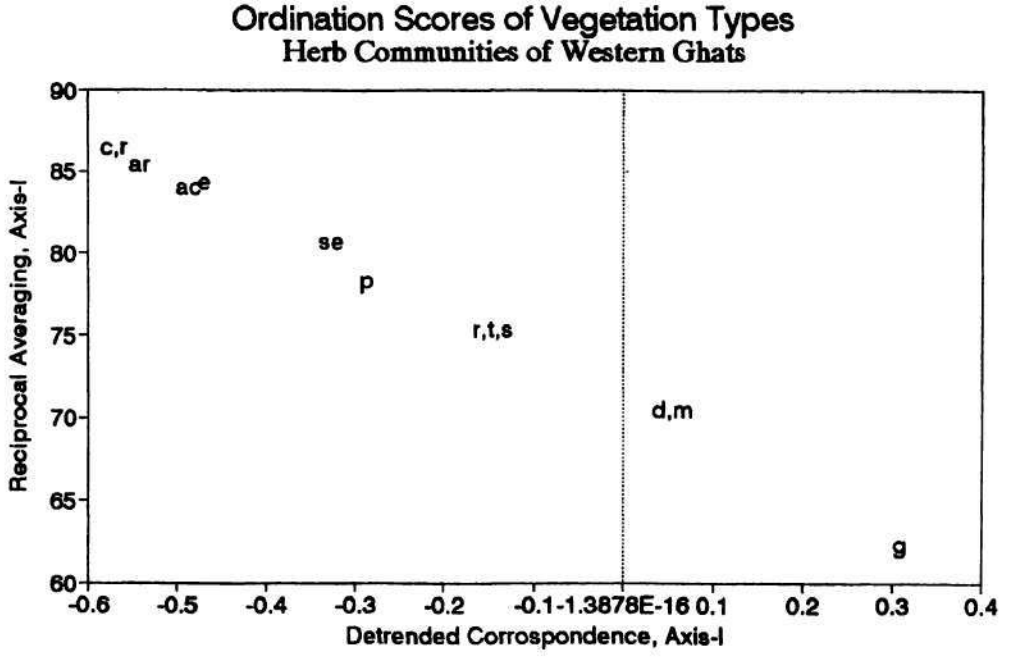


Figure 4 : The species richness and abundance of individuals across vegetation types.

Abbreviatios used : ac - acacia casurina plantations, ar - arecanut orchards, cr - coconut, rubber orchards, p - paddy field, g - grasslands, rts - rocks, thrickets, scrubs, dm - dry moist deciduous forests, se - semi evergreen forests, e - evergreen forests.

Note: Observe the lack of correlation betweeen the density ;o;of individuals and species richness across vegetation types. All the forests types are characterised by low herb density, between the deciduous forests are least diverse, evergreen - semievergreen forests are most species. Other natural vegetation types have greatest density values of individuals are psecies poor or moderately with moderate density and variabled diversity.

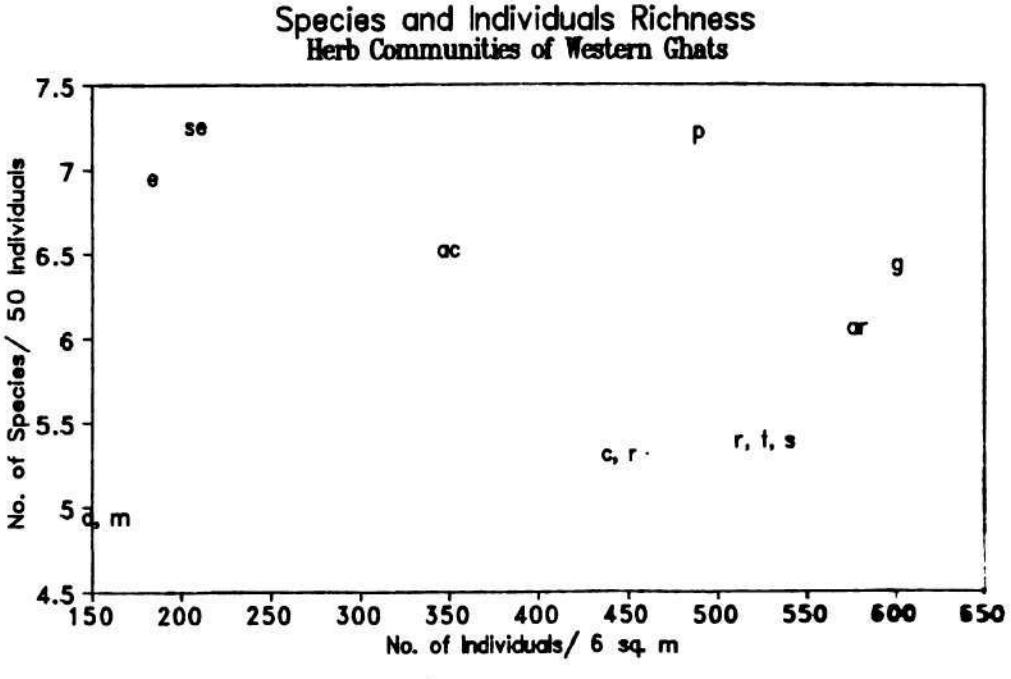


Figure 5 : The significant correlation between frequency and abundance on a semi-log scale.

Explanation:

Frequency indicates number of transects from which the species was recorded, abundance indicated total No. of individuals of the species from all these transects.

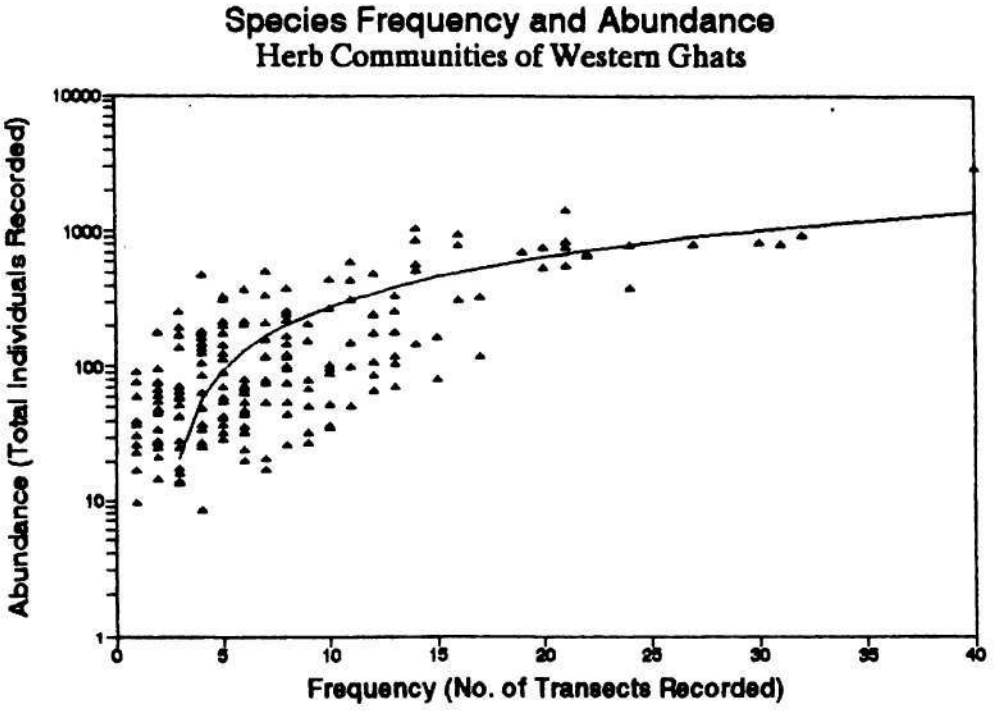


Figure 6 : The lack of correlation between frequency of a species and the species dissimilarity between the sites it inhabits.

Relationship between species frequency and heterogenety of its associate species.

Note: The frequency of species is not correlated with the species dissimilarity as measured by the chord distance, between the transects that the species inhabits. The transects are average dissimilarity between transects occupied by common species is more as expected however the species occurring in fewer transects show greater variation, some inhabiting sites with more similar species composition, while others with more distinct composition. Since these two parameters are uncorrelated we have posted them together to define the species nichewidth.

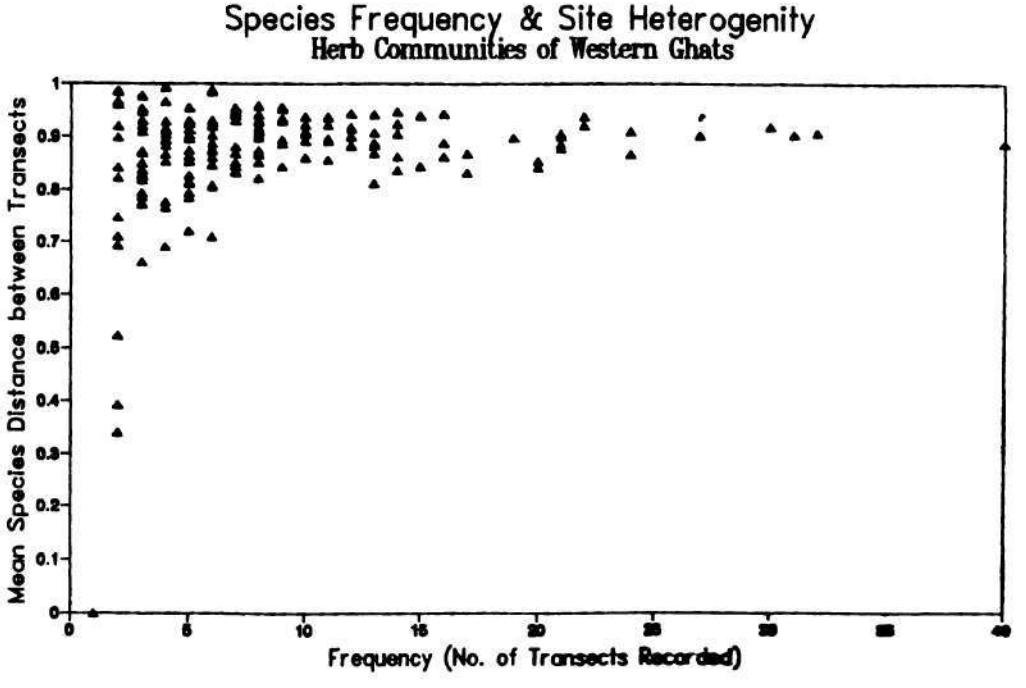


Figure 7 : The lack of correlation between the nichewidth and dominance of the species.

Nichewidth and mean Dominance of species.

Note: The nichewidth of a species and its mean dominance an index of local abundance, are not correlated. Thus we have all sorts of species from those widely distribution but locally dominating.

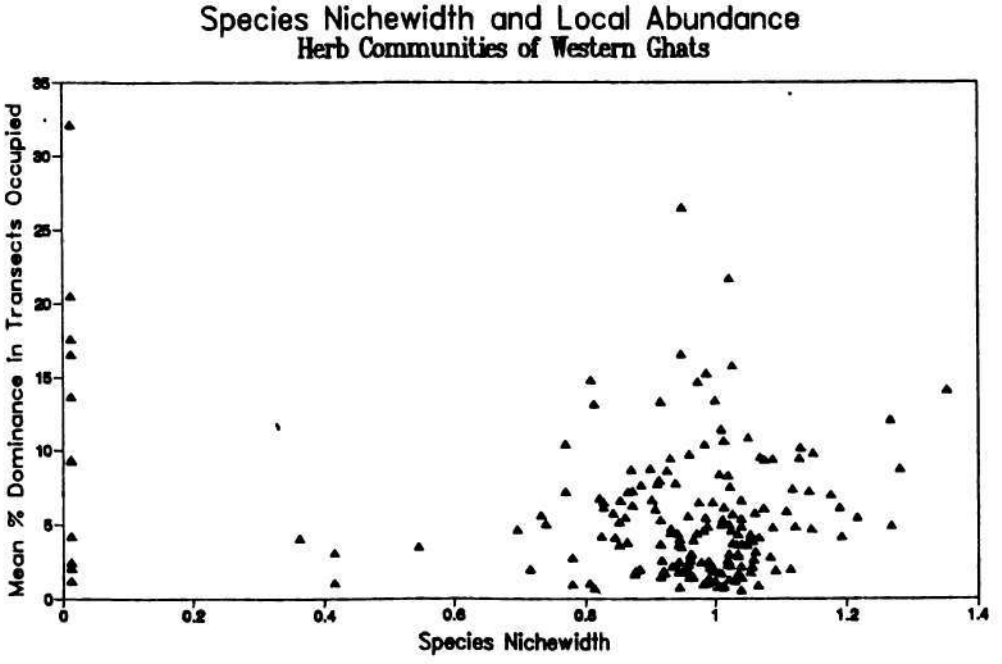


Figure 8 : The uncorrelated mean species and nichewidth dominance values of vegetation types.

Abbrevations used:- ac - acacia casurina plantations, ar - arecanut orchards, cr - coconut rubber orchards, p - paddy field, g - grasslands, rts - rocks, thrickets, scrubs, dm - dry moist deciduous forests, se - semi evergreen forests, e - evergreen forests.

Note:- The types with higher mean species niche-width do not necessarily have species with higher mean dominance. These two parameters are not well correlated.

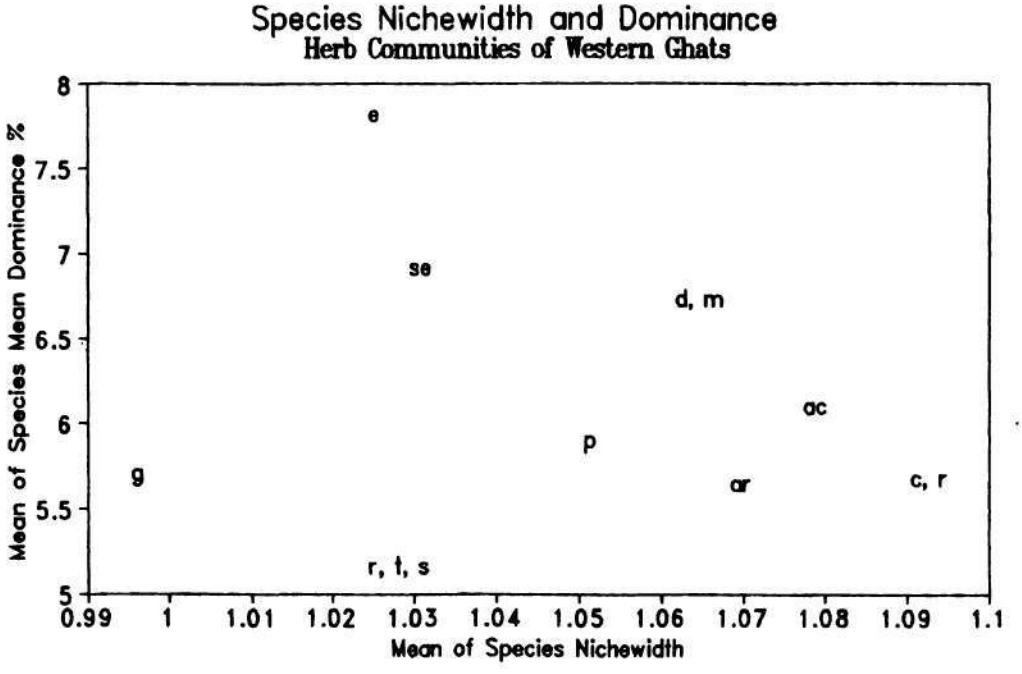


Figure 9 : The uncorrelated species nichebased conservation value and species dominance based conservation value of vegetation types.

Conservation values of vegetation types, based on nichewidth and rarity of constituent species.

Note:- The vegetation types with low mean nichewidth of constituent species have been assigned higher conservation value also, vegetation types with low over age mean species dominance have been assigned higher conservation value both the correlation value estimates are scale between 0 to 100; based on individual transects, since these two parameters seem to be uncorrelated we combine them to assign composite conservation value.

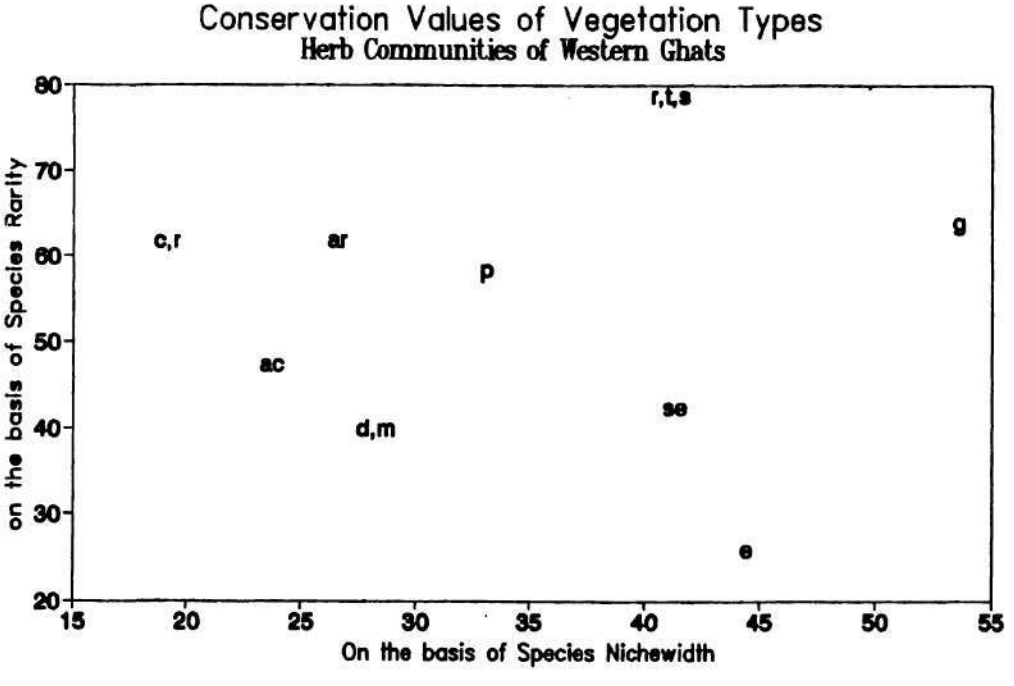
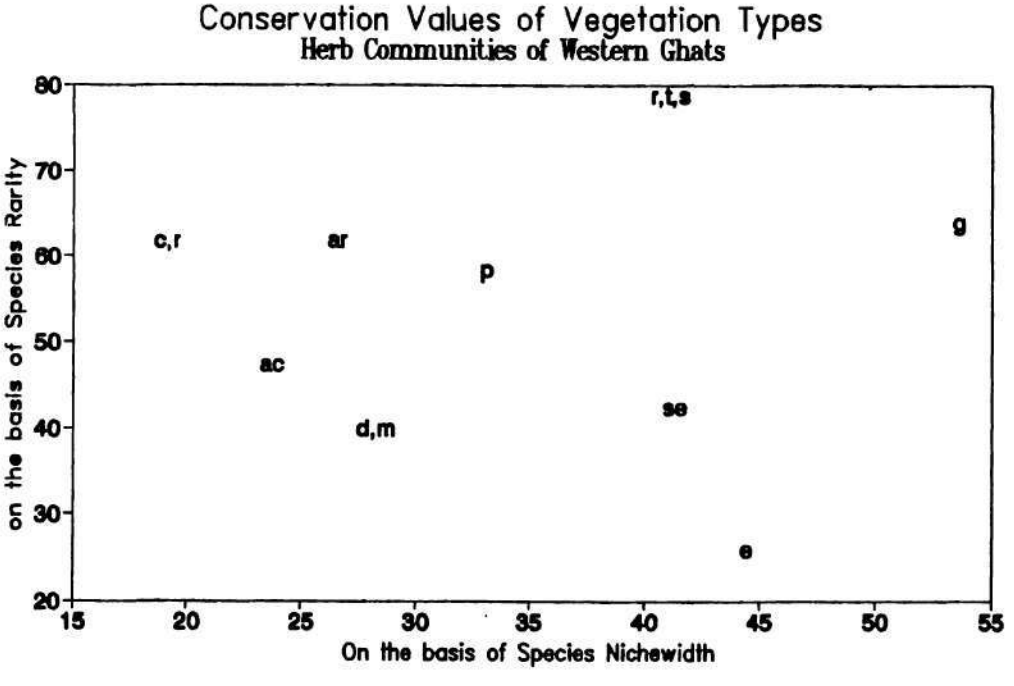


Figure 9 : The uncorrelated species nichebased conservation value and species dominance based conservation value of vegetation types.

Conservation values of vegetation types, based on nichewidth and rarity of constituent species.

Note:- The vegetation types with low mean nichewidth of constituent species have been assigned higher conservation value also, vegetation types with low over age mean species dominance have been assigned higher conservation value both the correlation value estimates are scale between 0 to 100; based on individual transects, since these two parameters seem to be uncorrelated we combine them to assign composite conservation value.



References:

1. Bor, N. L. 1960. The Grasses of Burma, Ceylon, India and Pakistan. Pregamon Press.
2. Cooke, T. 1901 - 1908. The Flora of Presidency of Bombay, Botanical Survey of India, Vol. I.
3. Daniels, R. J. R. Gadgil, M. 1991. Assigning Conservation Values.
4. Daniels, R. J. R. Gadgil, M., Joshi, N. V. 1995. Impact of Human Extraction on Tropical Humid Forests in the Western Ghats in Uttara Kannada, South India. Journal of Applied Ecology.
5. Gadgil, M. 1996. Documenting Diversity : An experiment. Curr. Sci. 70, 36 - 44.
6. Gamble, J. S. 1915 - 1935. Flora of the Madras Presidensy, Botanical Survey of India, vol. I.
7. Hawksworth 1995. Measuring and Monitoring Biodiversity.
8. Janzen, D. H. and Hallwards, W. 1994. All taxa biodiversity Inventory (ATBI) of terrestrial systems: A generic protector for preparing wild and biodiversity for nondamaging use. Report of a NSF workshop. 16-18 April 1993. Philadelphia, Pennsyvavia.
9. Gokhale, Y. 1997. Study of Vegetation Ecology of Semievergreen Forests of Western Ghats, Maharashtra (A Case Study of Phansad Wildlife Sanctuary in Raigad District) MSc. Thesis (under publication).
10. Nayar N. C. and Daniel P. 1986. The Floristic Diversity of the Western Ghats and its Conservation: A Review. Proc. Indian Acad. Sci. (Anim. Sci./ Plant Sci.)
11. Nayar, M. P. and Sashtry, A. R. K. (eds.) 1987-1990. Red Data Book of Indian Plants. vol. 1-3. Botanical Survey of India, Calcutta.
12. Saldhana C. J. and Nicolson Dan H. 1976. Flora of Hassan District, Karnataka, India: New Delhi.
13. Sivarajan V. V. and Mathew K. M. 1997. Flora of Nilambur. Bishen Singh Mahendra Pal Singh. Dehra Dun.
14. Sreekumar P. V. and Nair V. J. 1991. Flora of Kerala-Grasses. Botanical Survey of India.
15. Ter Braak 1986. Data Analysis in Community and Landscape Ecology.
16. Anonymous. 1996. The Ecodevelopment Plan for Village Sarva. Deputy Conservator of Forests. Roha.
17. Brower, J. Zar & C. V. Ende. 1989. Field and Laboratory Methods for General Ecology. Wm. C. Brown Publishers, Dubuque.

18. Daniels, R. J. R., M. Hegde & M. Gadgil. 1990. Birds of the Man Made Ecosystems: The Plantations Proc. Ind. Acad. Sci. (Anim. Sci.); Vol. 99, pp. 79-89.

19. Fosberg, F. R. 1961. A Classification of Vegetation for General Purposes. Trop. Ecol. 2:1 - 28.

20. Gadgil, M. 1994. Inventorying, Monitoring and Conservation India's Diversity. Current Science; Vol. 66, pp. 401-406

21. Gadgil, M. 1996a. Documenting Diversity: An Experiment. Current Science; Vol. 70, No. 1, pp. 36-44

22. Gadgil, M. 1996b. Western Ghats: A Lifescape. J. Ind. Inst. Sci. 76: 495 - 504.

23. Goldsmith, B. 1991. Monitoring for Conservation and Ecology, Chapman and Hall, London.

24. Greig Smith, P. 1983. Quantitative Plant Ecology, Blackwell. Oxford.

25. Ludwig, J. A. & J. F. Raynolds. 1988. Statistical Ecology: A Primer on Methods and Computing, John Wiley and Sons, New York.

26. Maguran, A. E. 1988. Ecological Diversity and its Measurement Princeton. University Press, New York, Pp 179.

27. Mueller-Dombois, D. & H. Elleinberg. 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons. New York.

28. Pascal, J. P. 1988. Wet evergreen forests of Western Ghats: ecology, Structure, Floristic composition and Succession. Inst. Fr. Pondi. Trav. de la Sci. et. Tech. Tome. XX bis. Pp 365

29. Pramod, P., N. V. Joshi, M. Gadgil. 1997a. On the Hospitality of Western Ghats habitats for Bird Communities. Curr. Sci. Special Issue on Western Ghats Habitats Biodiversity. Eds. Ganeshaiah and Umashankar.

30. Pramod, P., R. Daniels, N. V. Joshi, M. Gadgil. 1997b. Evaluating Bird Communities of Western Ghats to Plan for Biodiversity Friendly Development. Curr. Sci. Special Issue on Western Ghats Biodiversity. Eds. Ganeshaiah and Umashankar.

31. Puri, G. S., V. M. Meher-Homji, R. K. Gupta & S. Puri. 1983. Forest Ecology; vol, 1: Phytogeography and Forest Conservation. Oxford and IBH, New Delhi; pp. 583.

32. Saldhana, J. C. 1995. "Endemic Plants of Western Ghats". Report of Pitamber Pant Fellowship on Environment. Dept. of Envr. New Delhi.

33. Subhash Chandran, M. D. 1993. Vegetation Changes in the Evergreen Forest Tract of Uttar Kannada District of Karnataka State. Ph. D. Thesis, Karnataka University, Dharwad.

34. World Conservation Monitoring Centre, 1992. Global Biodiversity: Status of Earth's living resources. Chapman and Hall, London.

INSECT BIODIVERSITY IN WESTERN GHATS REGION OF KARNATAKA

A. K. Chakravarthy
Entomologist, University of Agricultural Sciences, Bangalore - 560 065

Introduction

Insects constitute the dominant group in the animal kingdom (Fig. 1) and are a major part of global biodiversity. Because of their small size, aerial mobility, dispersal, adaptability and evolved features, they are found in all biogeographical regions and ecological zones and have a dominating influence on biodiversity. Therefore insects are important.

The Western Ghats mountain range with evergreen tropical forests, spread over 1,75,000 km^2, is one of the 18 biodiversity hotspots of the world. This region, on various accounts is rapidly undergoing extensive changes. Fragmentation of habitats and isolation of animal populations because of human activities are causing inbreeding and populations may become non-viable and would be threatened with extinction. Therefore developmental projects in Western Ghats need to be carefully evalued from the view point of long term natual resource conservation and management. An attempt is made here to highlight some aspects of insect diversity in Western Ghats region, with particular refernce to Karnataka (W.G.K.).

Biodiversity

Biodiversity refers to the variety and variability of all animals, plants and microorganisms on earth and can be considered at genetic diversity, species diversity and habitat diversity. The important aspect is that it is the degree of variety in nature (Michael, 1991). A large portion of biodiversity is considered valuable because of the goods and services provided by species and the potential inherent in what has been described as the world's most fundamental capital stock.

Importance of insect Biodiversity

An insect species-diverse habitat performs valuable ecological processes because of

the interactions between species and enviornment (WRI, 1989). Ecological processes include bio-geo-chemical recycling, maintenance of soil fertility, water quality and climatic regulation. The relationship between biodiversity and ecological processes is neither simple nor clear. Many aspects of biodiversity cannot be re-created once lost. Limited knowledge of biodiversity leads to uncertainty, both scientific and economic. In the Indian context, the rate at which systematic studies are progressing, another 500 years could pass before taxonomy of the various groups of invertebrates including insects is completed. Insects occupy diverse niches and play many different functional roles in sustaining the dynamics of ecosystem . Insects and microorganisms play crucial roles in nature in decomposition. Insects are at work at the centre of all ecological processes, the reproduction of plant life. The economic value of insect-pollination is really great. The aesthetic value of wild flowers and butterflies is beyond economics.

The decomposition of plant and animal matters by fly maggots like blow flies, muscid flies, dung flies and beetles as dung beetles, scarabs and carrion beetles is essential to material recycling in ecosystems. Many predators such as green lace wings, lady beetles, predaceous flying beetles and ground beetles play an important role in regulating populations of pests (DeBach, 1974; Olembo, 1991). Arthropods are also major movers in subterranean ecosystems. Insects are a source for honey, silk and lac and these products are known to Indians from ancient times and are an item in all rituals, Smyrna fig, vanilla and cardamom are solely dependent on the activities of insect pollinators.

India constitutes 2% of land mass and accounts for 13% of about one million described species, making it one of the mega-diversity centres (Gadgil and Meher Homji, 1986). In India, Western Ghats are important in view of their genetic heterogeneity and species diversity. Unfortunately, very little is known about insects of this area. Many workers have drawn a check-list of groups of insects in small areas in Western Ghats region. A few, random examples are provided below.

Examples :

Ants

Rajagopal (1991) recorded 60 species of ants from Shiradi Ghats section, at four altitudes, Sakleshpur in Hassan to Uppinangadi in Dakshina Kannada district. These 60 species were distributed in 31 genera and six subfamilies of Formicidae. Based on frequency of occurrence and number of altitudes ants occurred, 15 species were categorized as rare and 16 species

the interactions between species and enviornment (WRI, 1989). Ecological processes include bio-geo-chemical recycling, maintenance of soil fertility, water quality and climatic regulation. The relationship between biodiversity and ecological processes is neither simple nor clear. Many aspects of biodiversity cannot be re-created once lost. Limited knowledge of biodiversity leads to uncertainty, both scientific and economic. In the Indian context, the rate at which systematic studies are progressing, another 500 years could pass before taxonomy of the various groups of invertebrates including insects is completed. Insects occupy diverse niches and play many different functional roles in sustaining the dynamics of ecosystem . Insects and microorganisms play crucial roles in nature in decomposition. Insects are at work at the centre of all ecological processes, the reproduction of plant life. The economic value of insect-pollination is really great. The aesthetic value of wild flowers and butterflies is beyond economics.

The decomposition of plant and animal matters by fly maggots like blow flies, muscid flies, dung flies and beetles as dung beetles, scarabs and carrion beetles is essential to material recycling in ecosystems. Many predators such as green lace wings, lady beetles, predaceous flying beetles and ground beetles play an important role in regulating populations of pests (DeBach, 1974; Olembo, 1991). Arthropods are also major movers in subterranean ecosystems. Insects are a source for honey, silk and lac and these products are known to Indians from ancient times and are an item in all rituals, Smyrna fig, vanilla and cardamom are solely dependent on the activities of insect pollinators.

India constitutes 2% of land mass and accounts for 13% of about one million described species, making it one of the mega-diversity centres (Gadgil and Meher Homji, 1986). In India, Western Ghats are important in view of their genetic heterogeneity and species diversity. Unfortunately, very little is known about insects of this area. Many workers have drawn a check-list of groups of insects in small areas in Western Ghats region. A few, random examples are provided below.

Examples :

Ants

Rajagopal (1991) recorded 60 species of ants from Shiradi Ghats section, at four altitudes, Sakleshpur in Hassan to Uppinangadi in Dakshina Kannada district. These 60 species were distributed in 31 genera and six subfamilies of Formicidae. Based on frequency of occurrence and number of altitudes ants occurred, 15 species were categorized as rare and 16 species

as endemic. Ali (1991 and 1992) reviewed the works of 41 workers on ant fauna of Karnataka and listed 125 species. He recorded 92 species from Western Ghats (W.G.) region of Karnataka. *Amblyopone rothneyi* (Forel), *Diacamma cyanei ventre* (Er. Andre), *Diacamma scalpratum* Fr. Smith, *Leptogenys dalyi* Forel are the species restricted to Western Ghats. *L. dalyi,* L. *dentilobis* Forel, *Odontomachers simillimus* Smith, *O.transversa* Fr. Smith, *Pachycondyla luteipes* Mayr and *P. melaniaria* Emery are endangered species.

Vastrad et al., (1991) recorded 30 species of grasshoppers from 1985 to 1988 at Prabhunagar, Dharwad, which is mostly a deciduous forest with much of the rainfall being received during March to August. Majority of the 30 species fell under gramincoles and herbicoles. Usman and Puttarudraiah (1955) listed short-horned grasshoppers from Karnataka. The Indian fauna of grasshoppers was first studied by Kirby (1914). Prasad and Viraktamath (1991) provided keys for 59 species of short-horned grasshoppers of Karnataka under two families.

Acrididae and Pyrgomorphidae of Acridoidea. Muralirangan *et al.*, (1993) determined species diversity, density and distribution in a part of Western Ghats region of Tamil Nadu Forests which harboured 52 of the 60 species collected. *Brachycrotaphus indicus, Zarytes squalina, Bababuddinea bizonata, Chitaura indica* and *Ceracris nigricornis* were rare species encountered. With increasing stress on tropical fauna, a general decline in total number of species can be expected.

Termites

Termites are the dominant soil fauna widely distributed in the Western Ghats. Majority of the termite species are significant detrivores as they carry subsoil to the ground to cover the litter and logs in the forest. *Odontoterms redemanni* is a major species distributed in all habitats and altitudes. Similarly, *O. horni* is equally dominant as subterranean species found in all habitats. *O.redemanni* and *O.horni* cultivate fungus combs in nests. The mound soil and fungus combs are nutritive and influence secondary succession in forests. The deserted termitaria are occupied by other wild animals such as rodents, lizards, birds, etc. The non-fungus termites, viz. *Microcertotermes, Nasutitermes indicola, Alstonitermes* species and *Trinervitermes biformis* are common (Rajagopal, 1993). Rajagopal (1991) found 11 species of termites at four altitudes from Sakleshpur to Uppinangadi along N. H. No. 48 (Table-1).

Table - 1: Termites recorded from a part of Western Ghats

a)	*Odontotermes obesus*	Mound building
b)	*O.redemanni*	-do-
c)	*O.oberi*	-do-
d)	*Macrotermes estherae*	Subterranean
e)	*Trinervitermes bioformis*	-do-
f)	*Speculitermes cyclops*	-do-
g)	*Dicuspiditermes incola*	-do-
h)	*Pericapritermes sp.*	-do-
i)	*Captotermes beimi*	-do-
j)	*Nasutitermes indicola*	arboreal nest
k)	*Microcerotermes fletcheri*	-do-

Moths and Butterflies

Satish (1996) recorded 13 species of moths and 16 species of butterflies from 3 km^2 area of the campus of Kuvempu University, Shimoga in one year. Gunathilagaraj et al., (1997) recorded 104 species of butterflies from Coimbatore in 1991-1995. Two peirid butterflies, viz. *Anaphoeis mesentina* Cramer and *Appias hippo* Cramer recorded by Ayyar and Ayyar (1933) were not observed by these workers. *Spindasis elima* Moore was recorded for the first time from Coimbatore. Important sighting was that of *Castalius rosimon* (Fab), one of the protected butterflies under the Wildlife Protection Act (1972), near Maruthamalai. If Coimbatore is allowed to maintain greenery like in the campuses of Tamil Nadu Agricultural University, Bharathiar University and Institute of Forest Genetics and Tree Breeding, it will remain beautiful! Butterflies contribute a great deal to our interest and fascination and are prominently used as natural symbols in art and literature of all cultures (*Pyle et al.,* 1981).

The Western Ghats are a focal point of endemic biodiversity of butterflies, especially *Colias hyale.* It is an endemic species listed under Indian Wildlife Protectiom Act, (1972) and it merits conservation status (Wyner-Blyth, 1957). *Colias hyale* is a pale clouded yellow butterfly seen throughout the year in Maruthamalai hills, and efforts are underway for *in situ* conservation (Santhilnathan *et al.*, 1997). Harish Gaonkar (1996) has listed 330 species of butterflies from the Western Ghats. (Tables 2 to 4).

Table-2 : Butterflies of the World, The Indian Region : Western Ghats and Sri Lanka

Butterflies of the World		Indian Region	Western Ghats	Sri Lanka
Papilionidae :	573	107	19	15
Pieridae:	1200	109	33	27
Nymphalidae :	6000	521	96	71
Lycaenidae :	6000	443	101	81
Hesperiidae:	3050	321	81	48
Total species :	16823	1501	330	344

From : The Butterflies of the Western Ghats, India and Sri Lanka, a Biodiversity Assessment : Harish Gaonkar 1996

Table - 3 : Butterflies of the Western Ghats : Papilionidae, Pieridae, Nymphalidae, Lycaenidae, Hesperiidae

FAMILIES		STATES					
BUTTERFLY FAMILIES		KE	TN	KA	GO	MH	GU
Papilionidae	19(8)	19(8)	19(8)	19(8)	18(7)	13(3)	11(2)
Pieridae	33(6)	31(6)	31(6)	29(5)	27(4)	24(2)	23(1)
Nymphalidae	96(20)	95(20)	94(19)	92(17)	70(8)	59(5)	41(2)
Lycaenidae	101(15)	93(13)	97(15)	98(14)	78(8)	71(5)	51(4)
Hesperiidae	81(12)	76(12)	75(12)	78(12)	56(7)	40(2)	32(2)
Total Butterfly species in Western Ghats : 330(61)		314(59)	316(60)	316(56)	249(34)	207(17)	158(11)

KE= Kerala; TN=Tamil Nadu; KA=Karnataka; Go=Goa; MH= Maharashtra; Gu=Gujarat

Table-4 : Butterflies of the Western Ghats and Sri Lanka

Butterfly Families	Faunal Centres (Hot spots)	
Diversity of Butterflies	Western Ghats	Sri Lanka
Papilionidae	19(8) (5)	15(5) (2)
Pieridae	33 (6) (3)	27(5) (1)
Nymphalidae	96(20) (12)	71(12) (7)
Lycaenidae	101(15) (5)	83(17) (8)
Hesperiidae	81(12) (12)	48(3)(3)
Butterfly species	330 (61) (37)	244(41) (21)

From : The Butterflies of the Western Ghats, India and Sri Lanka : A Biodiversity Assessment: Harish Gaonkar, 1996

Beetles

Beetles include the two largest families of animal or plant kingdom, Crysomelidae and Curculionidae with about 37,000 and 40,000 described species. Because of the variations in size, colour, shape, biology and elytral patterns, beetles exhibit a remarkable diversity and Coleoptera represents the largest order in class Insecta. Rajagopal (1991) recorded 40 carabid beetles in different habitatas at four altitudes from Western Ghats along National Highway No.48. Carabids were encountered at Nellyadi (26), Sakleshpur (12), Hongarahalla (9) and View point (6). Lower altitude recorded more number of species than habitats at higher altitudes. *Omphra pilosa* and *Tachys* sp. were found distributed at all the altitudes while *Diplocheila polita* was recorded in all the three altitudes except at 170m. All the four species of *Pheropsophus* were encountered only at higher altitude in Sakleshpur (940 m). Tiger beetles belong to family Cicindellidae and these are predatory in nature. These are brightly coloured beetles with long legs. Twenty-four species (larvae) were found at different habitats from Sakleshpur to Uppinangadi. Dung beetles belong to sub-family Scarabaeinae and Bruce Gill in 1984 recorded four new species of dung beetles in four days from Mudigere and Charmadi Ghats section. Arrow (1931) reported 357 species of dung beetles from the Indian sub-continent. Chakravarthy collected 19 species of Scarabaeid beetles in 3 months (June to August) from Madenur, Hassan in 1996 and 1997. Rajagopal (1991) recorded eight species of rootgrups (Table-5) along National Highway No.48.

Table-5 : White Grubs of a part of Western Ghats

1) *Anomala spp.*
2) *A.polita*
3) *Apogonia spp.*
4) *Autoserica sp.*
5) *Adoretus sp.*
6) *Holotrichia nr Sculpticollis Blanch*
7) *H.reynaudi Blanch*
8) *Mimela sp.*

From Rajagopal (1973).

Insect Fauna:

Some workers have sampled insects as a whole from study areas in Western Ghats. Gadagkar *et al.* (1993) collected ants from 12 localities in Western Ghats by a combination of quantitative sampling methods and all-out search. They collected 140 species of ants. These workers in 1990 endeavoured to standardize a package of methods for quantitative sampling of insects, suitable for tropics with modest budgets. The forests in Western Ghats have very rich and highly diversified soil insect fauna. A sampling of micro, meso and macro-fauna in four habitats, viz. less distributed forest, afforested land, deforested land grassland along National Highway No.48 from Sakleshpur to Uppinangadi revealed that ants, termites, collembola, psocids and carabids, were abundant in less disturbed forests (Rajagopal, 1993). Rajagopal (1991) conducted detailed studies on soil insects to include Collembola (20 species), Oribitid (930 species), Mesostigmata (16 species), ants (50 species), termites (15 species), carabid beetles (50 species), etc. from Western Ghats.

The Silent Valley National Park which represent the original habitat of the remote past is a typical humid tropical rainforest in the Kerala part of Western Ghats and forms the core area of Nilgiri Biosphere Reserve. It is situated on a plateau about 1000 m above mean sea level and covers an area of 900 ha. The relict characters of insect fauna are largely represented here. The Silent Valley forests, known as Syrandhrivanam represent one large "ecological island" in western ghats. In 90 km^2 area, 19 new insect species, 37 new insect species for western ghats, 8 new insect species for India and 15 endemic insect species were found in four faunal explorations of the Zoological Survey of the India between 1979 and 1980 (Radhakrishnan and Gopi, 1986)

These accounts only indicate the number of insects found but not the total species naturally occurring in that study area. These pieces of information needs to be collated and analysed and detailed surveys and monitoring programmes should be planned for the future.

Legislation

Insects generally have a poor image. Insects are generally considered a nuisance and are preferred dead. This is because mosquitoes, housefiles, eye files, lice and ticks are generally a source of terrible pain, muisance and are vectors for dangerous human diseases. The ecological roles played by insects are hardly recognised. Humans are much more dependent on insects than is generally thought; such as pollination of natural plants, crops and supperssion of pests (Morris et al., 1991). Insects need to be revered. An awareness is to be created that all arthropods including the creepy-crawlies are our fellow-creatures and they need to be preserved.

In India, insects are not adequately covered by legislation. The relict Himalayan dragonfly, *Epiophlebia laidlawi* which occurs in a few isolated and increasingly disturbed bio-types in Northern India and Nepal is a protected species of great taxonomic curiosity. This species has characters that link the two suborders of Odonata namely Zygoptera and Anisoptera and is protected under Indian Wild Life (Protection) Act, 1992 in which 452 species of butterflies have been included. As per the Act, collection and trade of these insects listed in Schedule-I, Part-IV is prohibited (Daniel and Walker, 1995). India should have a National Red Data Book on insects. The species survival commission of the IUCN has several specialist groups - Social Insects, Lepidoptera, Odonata, Orthoptera and Water beetles. Action plans are needed for important insect groups and the government of India in close cooperation arrangment with NGOs can establish a sound network to monitor and document insect species. This network can also kindle interest and promote interest in insects by school and college going children.

Trade

The Himalayas, like the Western Ghats are known as a paradise for naturalists. What is going on in the Himalayas will soon become true for the Western Ghats. The sparse places of refuge, where some portions of the original cover of the earth still remain are becoming gradually rarer and this attracts a large number of butterflies and consequently, butterfly hunters. In July, 1996 1,743 butterflies and 1420 beetles were collected from Eastern Himalayas by a Japanese. The seized specimens included 6 butterflies listed in Schedule-I of the Indian Wildlife (Protection) Act and another 14 listed in Schedule-II

(Part-II). It is estimated that 4,000 to 5,000 butterflies are exported illegally every year from Darjeeling alone, representing a value of about $2-2.5 million. Very few people are aware that hunting of butterflies is prohibited by law. No attention is being paid to insect fauna particularly of Western Ghats.

Sustainable Utilisation

To conserve biodiversity for sustainable ecosystems, we must know what remains of the global biodiversity, what ecological roles different species play and how the ecosystem processes function. In populous, developing countries like India, impacts on insect biodiversity cannot be treated in isolation, without regard to human communities. Western ghats forests may provide a stock of indigenous natural predators for suppression of phytophagous crop pests. In India annual crop losses due to pests range from 10-30%, at an estimated cost of Rs. 600 to 700 crores. Biological control is likely to be the most sought after the tool for pest suppression. Insecticidal properties can be found in plant species and the Western Ghats contain many scarcely known or even unknown plant species that might prove useful or may possess insecticidal properties.

Biotechnology requires access to the knowledge of species and a wide range of genetic resources. Future advances of biotechnology will be closely tied to new wild germplasms for breeding pest/disease resistant cultivars. Thus, due to the intricate ecological roles insects play in nature, any loss of insect species will deplete ecological and economical services they render. Since Western Ghats are rich in insect species diversity, their conservation is particularly important. All the published and unpublished information avalable with the local communities about biodiversity must be made available in a publication. Efforts in this direction are underway by the Western Ghats Biodiversity Network (WGBN) project - at Center for Ecological Studies(CES), Indian Institute of Science(IISc), Bangalore.

Insects are not distributed evenly in nature. In Kerala part of the Western Ghats, in the eastern border of Pathanamthitta district, in a 100 m2 stretch, on a day, 300 species of insects were found. Study of 4 Dipteran families alone yielded 12 species and one genus new to science and endemic to this stretch (Cherian, 1996). Conservation of endangered and endemic insect species is recognised as a vital need for a sustainable world in view of the critical roles insects play in nature. The Western Ghats enviornment will get worse with rapidly increasing human population and economic development where both the qualitative and quantitative aspects of conservation are important. Lack of human appreciation of importance, coupled with the general disregard and dislike of insects, is an impediment to their conservation (Samways, 1993). Since only 7-10% of world's insects are described

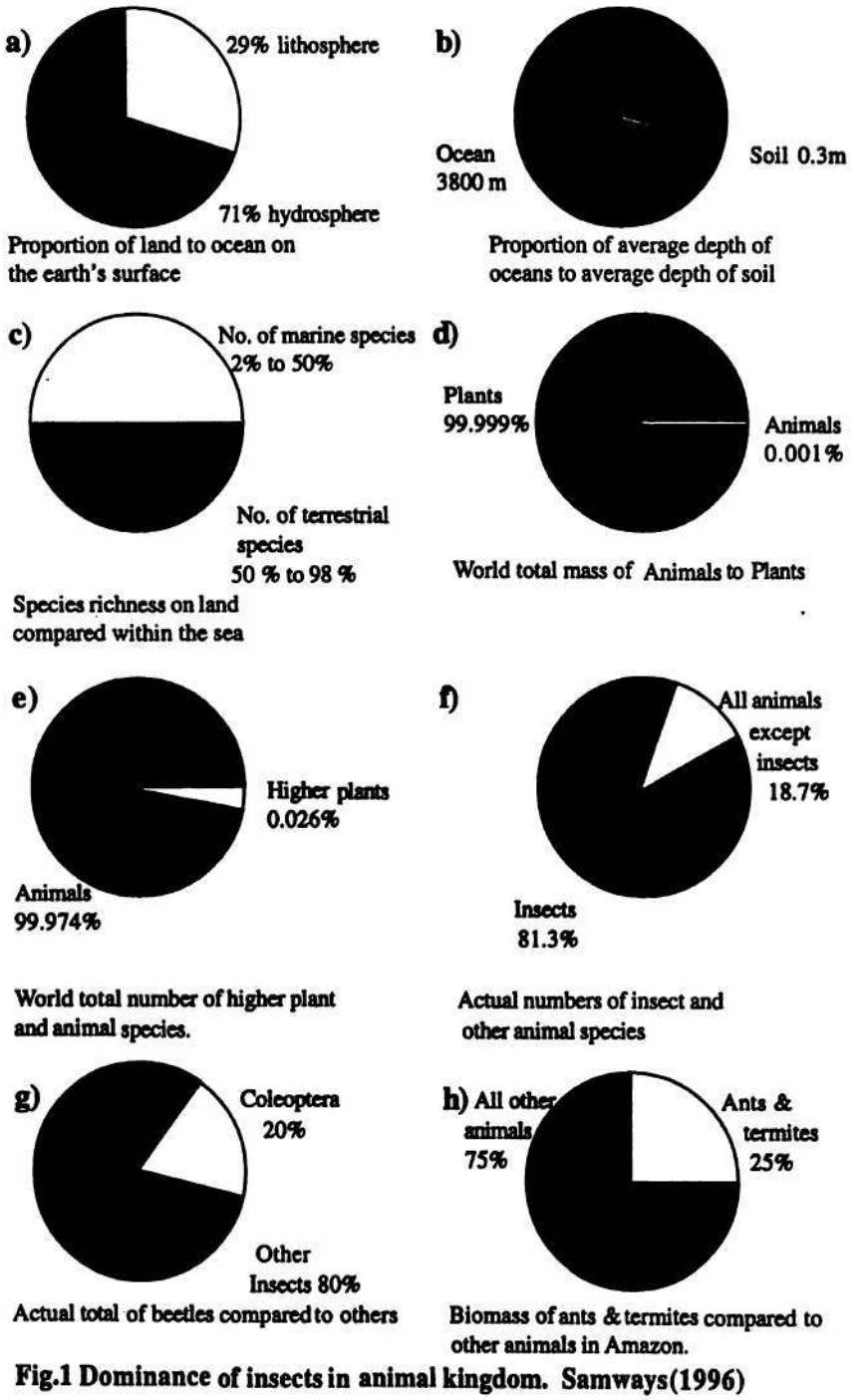


Fig.1 Dominance of insects in animal kingdom. Samways(1996)

and as it is not possible to know all the insect species and their significance and role, it is essential to conserve as many biotopes and landscapes as possible in the Western Ghats. There should be a strong focus on the preservation and conservation of as many insect species, and as large as possible, pristine and near-pristine unique and typical landscapes (Samways, 1993).

Recent expansive agricultural practises, driven by local needs and international markets, has been the principal cause for insect loss in the tropics. The rate of genetic loss in the tropics is enormous. There is an urgent need for management of insect population, so that insect pests on crops, livestock and other products are suppressed, while at the same time beneficial species are made use of.

References:

Arrow, G.J. 1931. The Fauna of British India including Ceylon and Burma. Coleoptera. Taylor and Francis, London, pp 428.

Cherian, P.T. 1996. Why Conserve Invertebrates? Zoos Print, January 1996, 1-2.

Daniel, B. A. and Walker, S. 1996. Handbook of Protected Invertebrates, Part-I, Butterflies (In preparation).

DeBach, P. 1974. Biological Control by Natural Enemies. New York: Cambridge University Press.

Gadagkar, R., Chandrashekara, K. and Nair, Padmini, 1990. Insect Species Diversity in the Tropics: Sampling Methods and a Case Study. J. Bombay Nat. Hist. Soc., 87(3) : 337 - 353.

Gadagkar, R., Nair and P. and Chandrashekar, K. 1993. Ant Species Richness and Diversity in Some Selected Localities in Western Ghats, India. Hexapoda, 5(2) : 79-94.

Gadgil, M. and Meher-Homji, V.M. 1986. Localities of Great Significance to Conservation of India's Biological Divesity, Proc. Indian Acad. Sci. Suppl. pp 165-180.

Gaonkar, H., 1996. The Butterflies of the Western Ghats, India and Sri Lanka. A Biodiversity Assessment.

Gunathilagaraj, K., Ganesh Kumar, M. and Ramesh, P. T. 1997. Butterflies of Coimbatore. Zoos Print XII (1) : 26-27.

Kirby, W. R., 1914. The Fauna of British India, including Ceylon and Burma. Orthoptera, London, IX, pp 276.

Michael, F. 1991. Biological Diversity and Developing Countries: Issues and Options. British Overseas Development Administration Approach Paper 50.

Muralirangan, M. C., Suresh, P. and Dhang, P.P. 1993. Observations on the Grasshopper Species

Diversity, Density and Distributional Pattern in Peninsular India. The Entomologist 112(3&4) : 201-210.

Musthak Ali, T. M. 1991. Ant Fauna of Karnataka - I. Newsletter of IUSSI Indian Chapter. 5(1&2) : 1-8.

Musthak Ali, T. M. 1992. Ant Fauna of Karnataka - II. Newsletter of IUSSI Indian Chapter. 6(1&2) : 1-9.

Olembo, R. 1991. Importance of Micro-organisms and Invertebrated as Components of Biodiversity. In: The Biodiversity of Micro-organisms and Invertebrates: Its role in sustainable Agriculture (D.L. Hawksworth, ed.), pp 7-16. Wallingford, U. K.

Prasad Kumar and Viraktamath, C. A. 1991. Illustrated Keys for Identification of Common Species of Short-horned Grasshoppers of Karnataka and Notes on Their Ecology and Behaviour. Hexapoda, 3(1&2) : 53-70.

Pyle, R., Benzien, M. and Opler, P. 1981. Insect Conservations. Ann. Rev. Ent. 26 : 233-258.

Radhakrishnan, C. and Gopi, K. C. 1996. Faunal Diversity of Silent Valley National Park. ZSI, Kozhikode (Mimeographed), pp 12.

Rajagopal, D. 1991. Annual Report. Studies on Soil Fauna, their Diversity and Relationship to the Ecosystem in Western Ghats. Mimeographed, pp.17.

Rajagopal, D. 1993. Annual Report. Studies on Soil Fauna their Diversity and Relationship to the Ecosystem in Western Ghats. Mineographed. pp 48.

Samways, M. J. 1993. Insects in Biodiversity Conservation : Some Perspectives and Directives. Biodiv. Conserv. 2 : 258-282.

Satish, P.M. 1996 : Moths and Butterflies of Bhadra Reservoir Project. M. Sc. Thesis submitted to Kuvempu Unviersity, Shimoga, pp.80.

Santhilnathan, S., Murugan, K. and Senthil Kumar, N. 1997. Status of *Colias hyale* in Western Ghats. Insect Enviornment 3(1) : 16.

World Resources Institute, 1989. Keeping Options Alive. Scientific Basis for Conserving Biodiversity.

Wynter-Blyth, M.A. 1957. Butterflies of the Indian Region. First Edition. The Bombay Natural History Society, Bombay, pp. 523.

Usman, S. and Puttarudraiah, M. 1955. A List of the Insects of Mysore including Mites. Bull. Dept. Agric. Mysore (Ent.) No. 16 : 4-8.

Vastard, A.S., Rai, P.S. and Lingappa, S. 1991. Ecological Distribution, Life Forms and Food Habits of Grasshoppers in Dharwad Region. Hexapoda 3 (1&2) : 94-97.

Amphibian Diversity In A Few Selected Environs Of Western Ghats

S. V. Krishnamurthy
Department of PG Studies and Research in Environmental Science,
Kuvempu University, Jnana Sahyadri - 577 451,
Shimoga District, Karnataka

Abstract

This paper details the amphibian diversity recorded from Kudremukh National Park, surroundings of Sringeri and Lakkavalli State Forest regions of Western Ghats. Over the period of study, 35 and odd species of amphibians (including 5 species of apodans) were encountered each from Sringeri and Kudremukh National Park. While 20 and odd species (including 2 species of apodans) were recorded from Lakkavalli State Forest. Overall, in Sringeri and Kudremukh National Park, there are 14 species depending upon their habitat. An overall survey depicts that the forms of the terrestrial habitat predominates (26%) followed by semiaquatic and arboreal (21% each), and then the aquatic (17%) and fossorial (15%) forms. Further, according to IUCN Red List categories, the ampibian fauna of Sringeri and Kudremukh National Park possess 3 endemic and 7 vulnarable species. The common threats for amphibian species of this terrain are agriculture related man-made activities.

Introduction

The Indian sub-continent offers one of the most diverse habitats with a variety of climates, vegetation and topography, which has facilitated a scope for harbouring a rich array of flora and fauna (Jayaram, 1974). Especially, the Western Ghat belt is known to offer the most congenial microhabitats for several endemic varieties of amphibians. This has been evidenced by recent calculation on amphibian diversity in BCPP (Biodiversity Conservation Prioritisation Program) CAMP (Conservation Assessment Management Plan) 1997 (Sanjay, 1997). According to this report, out of 207 Indian amphibians nearly 60% (125 species) are confined to Western Ghats. Further, out of these 125, about 93 species are strictly endemic to Western Ghats (see Table 1). Although overviews on amphibians of India, documented from time to time, have always added newer species to the earlier list, it is thought that the true diversity of Indian amphibians is greater than that is already known. (Inger and Dutta, 1986; Krishnamurthy and Katre, 1993) Meanwhile, even in Western Ghats, the amphibian population

is under the threat from man-made habitat alteration and other agriculture related activities. (Daniels, 1993; Krishnamurthy, 1996). Recently, considering the habitat alteration alone, there are some studies (Bury, 1983; Corn and Burg, 1991; Heang et al., 1996) detailing the diversity and distribution pattern of amphibians in neotropics and some part of oriental region respectively. Although the shrinkage in the habitat of Indian amphibians and decline in population in some part of the India are evident, the comparative studies on the wealth of amphibian diversity is limited. Considering these factors, this paper attempts to explain the diversity of amphibian in un-altered/virgin forests to altered habitats of a few selected parts of Western Ghats.

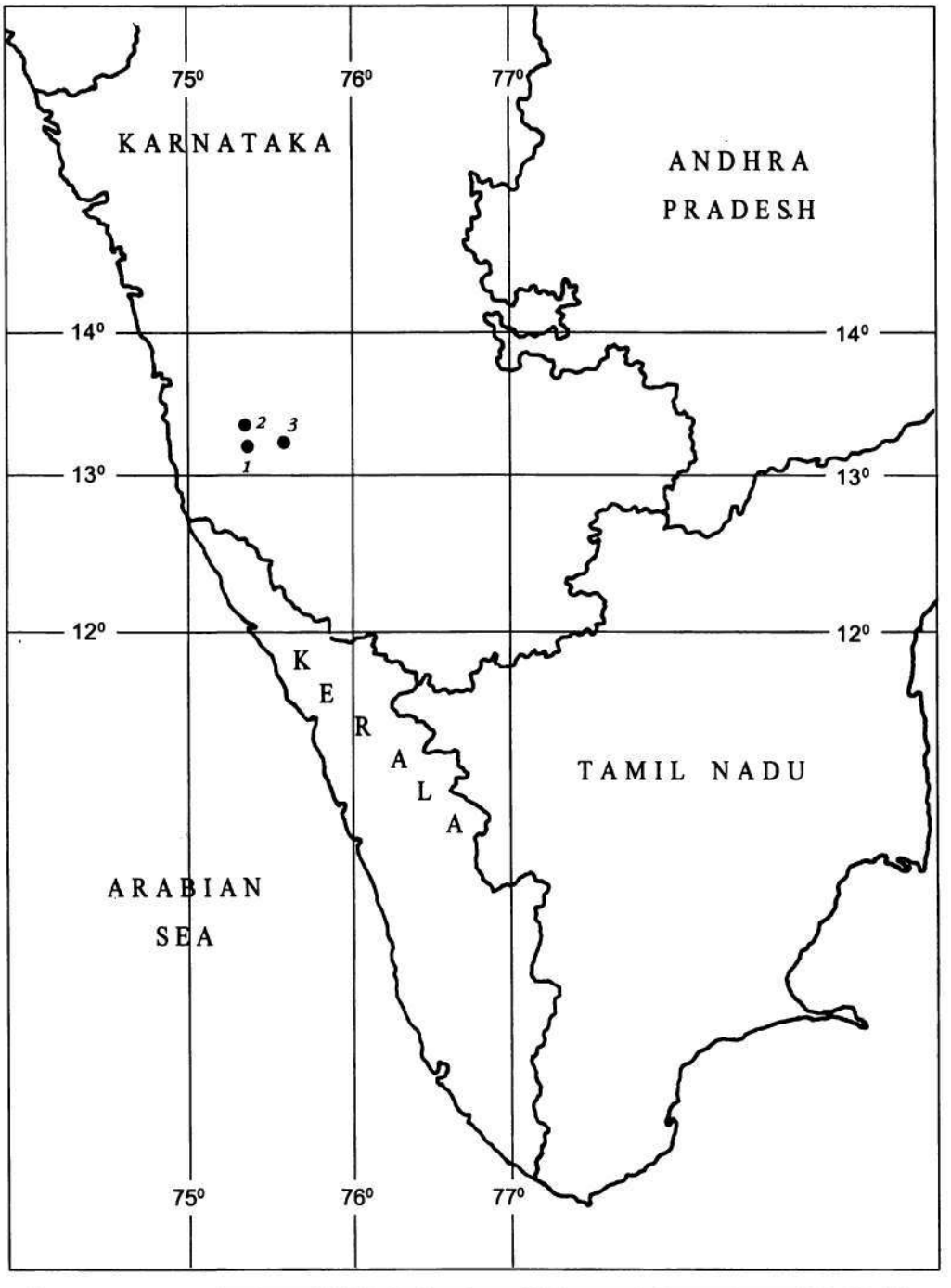
Areas of survey and methods

The study was carried out in three selected locations viz., Kudremukh National Park (Bhagavathi and Gangadikallu gudda forests), environs of Sringeri town and periphery of Lakkavalli State forests near Kuvempu University (Fig. 1). The topography of these areas ranges from steep to undulating terrain with outcrops of rocks on peaks and ridges. The altitude of the area ranges from 620m MSL to approximately 1500m MSL. The forest type of the study area is moist evergreen in Kudremukh, multistoried evergreen to mixed semi-evergreen in Sringeri and moist to dry deciduous forest in the margin of Lakkavalli State forests.

The forest in Kudremukh National Park is predominated by tree *Poeciloneuron indicum*, with a prominent thick canopy, blocking the sun-light reaching the forest floor which is almost free of undergrowth in the deeper valleys. The floor is matted with thick leaf litter deposits. However, in the open areas of the higher altitudes the ferns and grasses predominate. While around Sringeri, mixed vegetation including bamboo bushes were predominating with prominent multistoried nature and considerably high amount of litter in undisturbed forests. However, in Lakkavalli State Forests, the study area comprises bushy ground vegetation and secondary forests. The water regime and moisture content/relative humidity is high throughout the year in Kudremukh National Park and Sringeri region. Both regions are well watered by numerous seepage streams to tributaries passing through the valleys.

Survey and collection of amphibians was made between 1990-94 in the environs of Sringeri, while the observation and recording of amphibian species, habitat and distribution pattern are in progress since June 1996 in Kudremukh National Park and periphery of the Lakkavalli forest region. The surveys were carried out at different altitudinal and moisture gradients and also in different habitats like agricultural fields, plantations and waterbodies. In all surveys, every possible microhabitats were searched for the availability of amphibian species. The majority of the collections were made during early hours of the morning, late hours of the evening and sometimes also at nights. As far as possible, in all the surveys,

Figure 1. Study area; 1 = Kudremukh National Park, 2 = Sringeri and 3 = Lakkavalli Forest.



species collected in the field were identified on the spot but some species which were problematic in taxonomic approach were thoroughly checked and compared with museum specimens of the Bombay Natural History Society (BNHS) and Bangalore University. The taxonomic identification in the study followed the standard keys of Boulenger (1890 and 1920), Parker (1934), Rao (1937), Taylor (1968), Daniel (1963a, 1963b and 1975) and Daniel and Sekar (1989). A species list was prepared thereafter in the light of documented literature in systamatics of amphibian fauna of Western Ghats.

Species Composition

Table 2 details the species composition of amphibian recorded around Sringeri, Kudremukh National Park and Lakkavalli State Forest region of the Western Ghats. The total amphibian species recorded from this study are 35 each for Sringeri, Kudremukh National Park and 23 from Lakkavalli State Forest. Amphibian fauna of this region belonging to two orders viz., Anura and Apoda, comprises four and two families respectively. Among the anurans, the members of the family Ranidae predominanted (49%) both by number of species and occurrence. The predominating species among Ranidae are *Rana* (14 Species) while the order Apoda comprises two families, viz., Ichthyophidae and Uraeotyphlidae. The former is dominated by the members of genus Ichthyophis, while the latter is represented by only one species, *Uraeotyphlus narayani*.

Table 3 depicts the summary of occurrence, habitat characters, IUCN status and endemism based on the number of species. Common habitat preferred by maximum number of Ranids was aquatic, while the Rhacophoridae and Bufonidae strictly confined to arborial and terrestrial habitat respectively. However, most forms of Apoda, (both Ichthyophidae and Uraeotyphlidae, and a few forms of Anura (members of Ranidae) share the habitat or confined to semiaquatic to terrestrial habitats. It is interesting to note that maximum number of Ranids are litter dwelling forms.

The status of each amphibian species assessed according IUCN Red List categories are also depicted in table 3. Totally, there are 21 species which fall under Lower Risk Near Threatened (LRNT) followed by 7 species of Vulnerable (Vu), 4 species belonging to Lower Risk Least Concern (LRLC) and 3 species of endangered (EN) in nature. Under LRNT, again the Ranids predominate with *Rana* 9 species, *Nyctibatrachus,* and *Tomopterna* one species each. The vulnerable species recorded in this study are among Ranids: *Rana tigerina, R. limnocharis, R. beddomei* and *R. semipalmata* ; among Apoda, *Ichthyophis beddomei. I. malabarenis* and *Uraetyphlus narayani*. The endangered are two species of Ichthyophidae- *I. bombayensis* and *I. tricolor* and a species of Ranid - *Nyctibatrachus sanctipulustris*.

Totally, among the whole of amphibian diversity recorded, 21 species were strictly endemic to Western Ghats, in which the Ranids predominate (10 species) followed by members of the order Apdoa (5 species).

Threats to amphibians

Many significant threats to the amphibians of Karnataka were described by Daniels (1992). In the present study also, some important threats were recorded. However, the threats and the ultimate target species differed in different study locality. In the study sites of Kudremukh National Park, the threats as such for amphibian species are not noticed. While around Sringeri, and in the periphery of Lakkavalli state forest, the agriculture related habitat alteration, use of chemicals , fertilizers and pesticides are posing considerable problem to amphibian species.

Around Sringeri, however, denudation of the forest in the recent years is nearly absent but collection of leaf litter, scraping the dust, humus and mulch from the forest are in practice (Krishnamurthy, 1996). These activities not only reduce the microhabitat for litter frogs but also make the forest floor easily prone to erosion and subsequent siltation in the nearby water courses, consequently also reduces the microhabitat of aquatic forms. The amphibian species, facing the problem of organic mulch removal and siltation includes *Rana beddomei, R. temporalis, R. leithii* and *Nyctibatrachus major*. The second commonly observed threat is usage of chemical fertilizers, pesticide and lime in agriculture fields, Recently the availability of Apodan sp. (*Ichthyophis beddomei* and *I. bombayensis)* has been restricted to only those Areca gardens which are not treated with chemical fertilizer and lime. Further, because of leaching from agriculture fields the diversity of amphibian species is declining in the streams passing through agriculture land.

In the periphery of the Lakkavalli State Forest, excessive use of pesticides (Monocrotophos, Malathion and Dieldrin) is a severe problem. Eight Ranid species in this region which have intimate contact with agriculture field are severely affected. In addition, the monoculture plantation, as observed in the study, is also not encouraging the diversity of amphibians.

Discussion

Survival of man on this earth is always dependent upon ability to recognize, understand and utilize biological diversity (Blackmore, 1996). Although amphibians, unlike birds and mammals, are not important in seed dispersal, pollination or in herbivory, they neverthless

play an important role in controlling the insect population and as a prey for carnivorous birds and bats (Rand and Myers 1990). The Western Ghats of India are known to offer a rich amphibian diversity with high endemism (Inger and Dutta 1986, Daniels, 1992). The results of the present study depicts the richness of amphibian species even in the small localities of Western Ghats. In the present study, as many as 40 species of amphibians, of which 21 are endemic to the area, were recorded. This can be highly comparable to the total wealth of amphibian fauna of Western Ghats. According to recent BCPPCAMP - list of amphibians, there are 93 species occurring in Western Ghats as endemic to the area. In the present study even in these small localities nearly 23% of them were recorded, which strongly reflects the wealth and congenial conditions prevailing in this terrain.

Amphibians, as recorded in the present study, occupy all available habitats - such as seepage, marshes, riparian, agriculture fields, plantations, forest floor, bushes, understory, trunks of large trees, canopy, subterrain etc. However, the distribution of species in different habitats are considered under broader aspects of aquatic, semi aquatic, terrestrial, and fossorial. Further, in each habitat, most of species, although a few coexist, are confined to a narrow range of microhabitat. The changes in such habitats, due to man made activities, have created a problem of habitat shrinkage, decline in larval population and dispersion of young adults. This is more severe in the case of endangered and vulnerable species of poor dispersal capacity.

General concern about the effect of pesticides on non-target organisms like amphibians has been expressed in the developed countries (Cooke, 1981) and very limited in developing countries (Lambert, 1997). Amphibians are sensitive to a wide range of pesticides and have been reported to be declining on a worldwide scale (Wake, 1991; Blaustein and Wake 1995). On the whole of Western Ghats and also in the study localities, the agriculture fields and natural forest/terrains are interspersed and usage of pesticide, and chemical manure is severe, hence, there is a great possibility of further reduction in the population sizes. Since this area harbours 3 endemic and 4 vulnerable species, it is high time to consider the research needs to study the threats of pesticides to conservation of amphibian diversity of Western Ghats.

In the present study, the amphibians occured throughout the study area and many species were often conspicuous and abundant in natural habitats. But the monocultured plantations, which have also fragmented the virgin forests and occupied the hill tops, except during the rainy season, do not support amphibian diversity.

play an important role in controlling the insect population and as a prey for carnivorous birds and bats (Rand and Myers 1990). The Western Ghats of India are known to offer a rich amphibian diversity with high endemism (Inger and Dutta 1986, Daniels, 1992). The results of the present study depicts the richness of amphibian species even in the small localities of Western Ghats. In the present study, as many as 40 species of amphibians, of which 21 are endemic to the area, were recorded. This can be highly comparable to the total wealth of amphibian fauna of Western Ghats. According to recent BCPPCAMP - list of amphibians, there are 93 species occurring in Western Ghats as endemic to the area. In the present study even in these small localities nearly 23% of them were recorded, which strongly reflects the wealth and congenial conditions prevailing in this terrain.

Amphibians, as recorded in the present study, occupy all available habitats - such as seepage, marshes, riparian, agriculture fields, plantations, forest floor, bushes, understory, trunks of large trees, canopy, subterrain etc. However, the distribution of species in different habitats are considered under broader aspects of aquatic, semi aquatic, terrestrial, and fossorial. Further, in each habitat, most of species, although a few coexist, are confined to a narrow range of microhabitat. The changes in such habitats, due to man made activities, have created a problem of habitat shrinkage, decline in larval population and dispersion of young adults. This is more severe in the case of endangered and vulnerable species of poor dispersal capacity.

General concern about the effect of pesticides on non-target organisms like amphibians has been expressed in the developed countries (Cooke, 1981) and very limited in developing countries (Lambert, 1997). Amphibians are sensitive to a wide range of pesticides and have been reported to be declining on a worldwide scale (Wake, 1991; Blaustein and Wake 1995). On the whole of Western Ghats and also in the study localities, the agriculture fields and natural forest/terrains are interspersed and usage of pesticide, and chemical manure is severe, hence, there is a great possibility of further reduction in the population sizes. Since this area harbours 3 endemic and 4 vulnerable species, it is high time to consider the research needs to study the threats of pesticides to conservation of amphibian diversity of Western Ghats.

In the present study, the amphibians occured throughout the study area and many species were often conspicuous and abundant in natural habitats. But the monocultured plantations which have also fragmented the virgin forests and occupied the hill tops, except during the rainy season, do not support amphibian diversity.

Table-1 : Family wise-composition of Indian amphibians

No.s of Species			
	India	Western Ghats	
		Endemic	Non endemic
APODA			
1. Ichthyophidae	11	7	2
2. Uraeotyphlidae	4	4	-
3. Caecilidae	4	3	-
URODELA			
1. Salamandridae	1	-	-
ANURA			
1. Bufonidae	21	9	5
2. Bufoninae	1	-	-
3. Hylidae	1	-	-
4. Pelobatidae	10	-	-
5. Microhylidae	17	6	6
6. Ranidae	77	35	11
7. Rhacophoridae	60	29	6
Total	207	93	30

(Source : Sanjay. 1997)

Table-2 : Species composition of amphibian fauna in the study area

Species	Occurrence			Habitat	IUCN Status	Endemism
	SRG.	KNP	LSF			
ANURA						
1. *Rana hexadactyla*	+	-	+	Aq	LRNt	
2. *R. cyamophlyctis*	+	+	+	Aq	LRNt	
3. *R. tigerina*	+	+	+	Aq	Vu	
4. *R. keralensis*	+	+	+	SA	LRNt	E (W+EI)
5. *R. limnocharis*	+	+	+	SA	Vu	
6. *R. greeni* ?	+	+	+	SA	LRNt	
7. *R. doriae* ?	+	+	-	SA,L	LRIC	
8. *Rana (Tomopterna) rufesence*	+	+	+	T/F,L	LRNt	E
9. *R. beddomei*	+	+	-	T,L	Vu	E
10. *R. leithii*	+	+	+	Aq	LRNt	E(W+C)
11. *R. semipalmata*	+	+	+	T,L	Vu	E
12. *R. curtipes*	+	+	+	T,L	LRNt	E
13. *R. aurantiaca*	+	+	-	T,L	LRNt	E
14. *R. temporalis*	+	+	+	T,L	LRNt	
15. *R. malabarica*	-	-	+	T,L	LRNt	E(W+E+C)
16. *Nyctibatrachus major*	+	+	-	Aq,	L LRNt	E
17. *N. pygmaeus*	+	+	-	Aq,L	-	
18. *N. sanctipalustris*	+	+	-	Aq,L	EN	E

Occurrence : SRG = Around Sringeri, KNP.= Kudremukh National Park, LSF= Lakkavalli State Forest. + Present; - Absent

Habitat : Aq = Aquatic, SA=Semi Aquatic, T = Terrestrial, L= Litter species

IUCN Status : LRNT = Lower Risk Near threatned, LRCD = Lower Risk Conservation Dependent, LRLC = Lower Risk Least Concern, Vu = Vulnerable, EN = Endangered

Endemism: E= Endemic to Western Ghats, E(W+EI) = Endemic to Western Ghats and Eastern India, E(Wtc) = Endemic to Western Ghats and Central India, E(W+E+C) = Endemic to Western Ghats, E (W+E) = Endemic to Western Ghats and Eastern Ghats.

II. RHACOPHORIDAE						
19. *Rhacophorus malabaricus*	+	+	-	A	LRNt	E
20. *Polypedatus maculatus*	+	+	-	A	LRIC	
21. *P leucomystaxt*	+	+	+	A	LRIC	
22. *Philautus leucorhinus*	+	+	+	A	LRIC	
23. *P pictus*	+	+	+	A	LRNt	
24 *P. nasutus*	+	+	+	A	LRNt	E
25. *P aurifasciatus*	+	-	-	A	-	
26. *P punctatus*	+	+	-	A	-	
27. *P. adespersus*	+	+		A	-	
III. MICROHYLIDAE						
28. *Microhyla ornata*	+	+	+	SA,L	LRNt	
29. *Microhyla rubra*	-	+	-	SA	LRNt	
30. *Ramanella montana*	+	+	+	F	LRNt	E
31. *Uperdon* sp	-	-	+	T	LRNt	
IV. BUFONIDAE						
32. *Bufo furgusoni*	-	-	+	T	LRNt	
33. *B. hololius*	+	+	-	T,L	LRNt	E(W+E)
34. *Bufo beddomei*	+	+	-	T	LRIC	E
35. *Bufo melanostictus*	+	+	+	T,L	LRNt	
APODA						
I. ICHTHYOPHIDAE						
36. *Ichthyophis beddomei*	+	+	+	F,SA	Vu	E
37. *I. bombayensis*	+	+	-	F,T	EN	E
38. *I. malabarensis*	+	+	-	F,T	Vu	E
39 *I. tricolor*	-	+	+	F,SA	EN	E
II. URAEOTYPHLIDAE						
40 *Uraeotyphlus narayani*	+	+	-	F,SA	Vu	E
Total	35	35	23			

Table-3 : Summary of the occurence, habitat, IUCN status and Endemism of amphibians

Genera	No. of species			Habitat						IUCN Status				Endemic to Western Ghats
	SRG	KNP	LSF	Aq.	SA	T.	A,	F,	L	LRNt	LRIC	Vu	EN	
ANURA														
1. *Ranidae*														
a. *Rana*	13	13	12	4	4	6	-	-	7	9	1	4	-	7
b. *Nyctibatrachus*	3	3	-	3	-	-	-	-	3	1	-	-	1	2
c. *Tomopterna*	1	1	1	-	-	1	-	-	1	1	-	-	-	1
	17	17	13	7	4	7			11	11	1	4	1	10
2. *Rhacophoridae*														
a. *Rhacophorus*	1	1	-	-	-	-	1	-	-	1	-	-	-	1
b. *Polypedatus*	2	1	-	-	-	-	2	-	-	-	2	-	-	-
c. *Philantus*	6	5	3	-	-	-	6	-	-	2	?	?	?	2
	8	7	3	-	-	-	9	-	-	3	2	-	-	3
3. *Microhylidae*														
a. *Microhyla*	1	2	1	-	2	-	-	-	1	2	-	-	-	-
b. *Ramanella*	1	1	1	-	-	1	-	1	-	1	-	-	-	1
c. *Uperdon*	-	-	1	-	-	1	-	-	-	1	-	-	-	-
	2	3	3	-	2	2	-	1	1	4				
4. *Bufonidae*														
a. *Bufo*	3	3	1	-	-	4	-	-	2	3	1	-	-	2
APODA														
1. *Ichthyophidae*														
a. *Ichthyophis*	3	4	2	-	2	2	-	4	-	-	-	2	2	4
2. *Uraeotyphidae*														
b. *Uraeotyphus*	1	1	-	-	1	-	-	1	-	-	-	1	-	1
Total	35	35	22	7	9	15	9	6	14	21	4	7	3	21

References

Blackmore.S. 1996. Knowing the Earth's Biodiversity : Challenges for the Infrastructure of Systematic Biology. Science, 274:63-64.

Blaustein, A. R., and D. B. Wake. 1995. The Puzzle of Declining Amphibian Populations. Scientific American, April 1995. 56-65.

Boulenger. G. A. 1890. Fauna of British India, including Ceylon and Burma: Reptilia and Batrachia. London.pp.432-541.

Boulenger. G.A. 1920. A Monograph of South Asian, Papuan, Melanesian and Australian frogs of the Genus Rana. Rec. Indian. Mus.20: 1-226.

Bury, R. B. 1983. Differences in Amphibian Population in Logged and Old Growth Redwood Forest. Northwest Science. 57(3): 167-178.

Cooke. A.S. 1981. Tadpoles as Indicator of Harmful Levels of Pollution in the Field. Environ.Pollut. Ser-A. Bio.Ecol. 25:43-50.

Corn. P.S. and R.B.Bury, 1991. Terrestrial Amphibian Communities in the Oregon Coast Range. *In* Wildlife and Vegetation of unmanaged Douglas Fir Forests. U.S.Dept. of Agriculture & Forest Service. General Technical Report PNW- GIR-285.pp.305-317.

Daniel. J.C. 1963 a & b, Field Guide to the Amphibians of Western India, J.Bombay Nat. Hist. Soc. 60:415-438 and 60: 690-702.

Daniel. J.C. 1975: Field Guide to the Amphibians of Western India, J.Bombay Nat. Hist. Soc. 72: 506-522.

Daniel J.C. and A.G.Sekar. 1989. Field Guide to the Amphibians of Western India. J.Bombay Nat. Hist. Soci.86: 180-202.

Daniels, R.J.R. 1992. Geographical Distribution of Amphibians in the Western Ghats, India. J.Biogeogr. 19: 521-529.

Daniels, R.J.R. 1992. The Amphibian Fauna of Karnataka. What does it suggest. Karnataka State Environment report V.79-85.

Heang. K.B., L.B.Liat and M.R.K. Lambert. 1996. To Determine the Effect of Logging, Timber Extraction, and Conservation of Primary Forest to Tree & Crop Plantation, on Herpetofaunal Diversity in Peninsular Malaysia. British Herpetological Society Bulletin. 57: 2-20.

Inger R.F. and S.K.Dutta. 1986. An Overview of the Ampibian Fauna of India. J.Bombay. Not. Hist. soc. 83: 135-146.

Jayaram. K.C. 1974. Ecology and Distribution of Freshwater Fishes, Amphibians and Reptiles. In: Ecology and Biogeography of India. (M.S.Mani ed.) 517-584. Dr. Junk. BV, The Hague.

Krishnamurthy S.V. and Katre Shakuntala. 1993. Amphibian Fauna of Sringeri Taluk (Chickmagalur District: Karnataka) J. Indian Inst. Sci. 73: 443-452.

Krishnamurthy S.V. 1996 Future of Some Anurans in the Malnad Region of Westerns Ghats. Zoos Print. XI (5): 9-11.

Lambert, M.R.K. 1997. Effects of Pesticides on Amphibians and Reptiles in sub-Saharan Africa. Rev.Environ Conta Toxicol. 150: 31-73.

Parker, H.W. 1934. A Monograph of the Frogs of the Family Microhylidae. Oxford Univ. Press.PP.208.

Rao, C.R.N. 1937. On Some New Forms of Batrachia From S.India. Proc. Indian. Acad. Sci. 6(6) : 387-427.

Rand.A.S. and C.W. Myers. 1990. The Herpetofauna of Barro Colorado Island, Panama; An Ecological summary. *In* Four Neotrophical Rainforests (A.H.Gentry, ed.). Yale Univ. Press New Haren.pp.386-409.

Sanjay M. 1997. All Indian Amphibians Assessed According to the new IUCN categories. Frogleg 2(1): 4-6.

Wake D.S. 1991. Declining Amphibian Populations. Science. 253: 860.

Mahseer, The Endangered Species : Need For Conservation

P. Keshavanath, and Iqlas Ahmed
Department of Aquaculture, College of Fisheries,
Mangalore - 575 002.

Mahseer has been recognized as one of the worlds best game fishes; it also has the qualities of a commercially important food fish. Mahseer has been listed as an endangered species by the Zoological Survey of India. Indiscriminate and destructive methods of fishing combined with habitat degradation are the major causes for the decline in mahseer stocks. The endangering of this majestic fish has threatened biodiversity. Hence, there is an urgent need to protect as well as propagate this fish and thereby preserve genetic diversity. Measures to propogate and conserve mahseer have been undertaken in different parts of India.

Two species of Mahseer, *Tor khudree and T. mussullah* have been recorded from Karnataka rivers, the former species being more abundant. Not long ago, the rivers of Karnataka had moderately high population of this fish. But, now excepting for a few pockets where sanctuaries exist, there is no trace of this ecologically important species. The Department of Fisheries, Government of Karnataka; Coorg Wildlife Society, Kodagu; Wildlife Association of the South India, Bangalore and a few other voluntary organisations have been striving to revive the mahseer fishery through replenishment of depleted stocks by ranching and conservation activities. The Department of Fisheries has been taking measures to protect even sancturies in view of a very recent revenge killing of mahseer in the Shishila sanctuary. Further, the Department of Fisheries has established a hatchery for the production of mahseer seed at Harangi in Kodagu, with a view to stock different rivers of the state.

Since mahseer is a slow growing fish, measures to hasten its growth in the early stages are of significance in propagation. Early growth rate of *Tor khudree* was investigated at the College of Fisheries, Mangalore under an ICAR funded research project, employing different formulated diets. Protein requirement of the species and feed utilisation were also studied. Some of the formulated diets induced faster growth of mahseer facilitating early stocking of the seed in natural waters. It has been observed that mahseer grows well in reservoirs.

Micro-level survey to identify the natural waters for the development of mahseer fishery, large scale artificial propagation, seed rearing for ranching, mass awareness programmes to save mahseer and strict enforcement of ban on destructive fishing are some of the measures suggested for the conservation of mahseer.

Mahseers inhabit water bodies ranging from a few meters to 2000 m above mean sea level and tolerate temperatures of 6 to 35° C. They are highly esteemed as food fish and fetch good market price in several parts of India. The importance of mahseers as world famous game fish is well known.

Interest in mahseers dates back to the 10th century. Hump back mahseer, *Tor mussullah* has been referred to by King Somesvara in his book *Manasolasa* (1127 AD). The Kingdom of Somesvara comprised practically the whole of Deccan plateau and included the Godavari, Narmada, Tapti and Krishna river systems. From Somesvara's chapter on angling *"Mathsyavinoda"* it can be surmised that the art of sports fishery was very much in vogue in Southern India even earlier to his time.

Mahseers are inhabitants of fast running streams with clear waters in the snow fed rivers of Himalayas and rock laden rapids of Peninsular India. They prefer rocky pools and cooler temperatures of the head waters of river moving up and down the stream depending on flood conditions.

As per the latest classification (Rainboth, 1990), 11 species of mahseers are known from its entire range of distribution in India, Pakistan, Nepal, Bangladesh, Burma and Sri Lanka. They are:

1. *Tor chilinoides* (McClelland). Foothills of Ganga river system.
2. *Tor curmuca* (Hamilton). Rivers of Western Ghats in the Deccan.
3. *Tor khudree* (Sykes). Peninsular India, especially Karnataka, Kerala, Maharashtra.
4. *Tor macrolepidota* (Day). Burma, Sri Lanka, Malay Peninsula.
5. *Tor mosal* (Hamilton). Burma, Sri Lanka, Kashmir, Sikkim, Assam.
6. *Tor mussullah* (Sykes). Deccan rivers - Kavery, Bhavani, Mula-Mutha.
7. *Tor neilli* (Day). Tungabhadra river, Krishna river system.
8. *Tor progenius* (McClellad). Assam, Arunachal Pradesh, Naga hills.
9. *Tor putitora* (Hamilton). All along the Himalaya from Kashmir to Assam, Nepal, Bangladesh, Pakistan.

10. *Tor tor* (Hamilton). All along the Himalaya, Madhya Pradesh, Bihar, North Bengal, Assam, Pakistan, Bagladesh.

11. *Tor zhobesis* (Mirza). Pakistan.

Tor neilli, however, is considerd to be synonymous with *T. khudree.*

Of these species *T. khudree* and *T. mussullah* inhabit streams and rivers of Karnataka. Karnataka state has been a favourite of many overseas anglers. Over a dozen very large mahseers, each weighing more than 100 pounds have been recorded from the Kavery river system. The all India record for the largest mahseers caught on rod and line since 1904 comes from Karnataka.

Tragically these majestic fishes have become a rarity, except at temple sanctuaries like Ramnathapura in Hassan district, Sringeri and Hariharapura in Chickmagalur district, Chippalgudda near Thirthally in Shimoga district, Shishila, Thodikana, Bachanayakana gundi and Thingale in Dakshina Kannada district. Indiscriminate and destructive methods of fishing coupled with habitat degradation have resulted in the decline of mahseer stocks endangering their very survival. This has prompted the Zoological Survey of India to list mahseers under the endangered species.

The decline in mahseer stocks has not only affected the sport fishery, but also uprooted many fishermen families dependent on them for survival. They have been forced to seek alternative means of livelihood. The endangering of mahseer has threatened biodiversity and hence there is an urgent need to conserve them.

Present status of Deccan mahseers

Accurate information on the status of reportedly threatened species are often scanty and difficult to obtain. Between the extinct category and an undisturbed healthy natural population, many different degrees of depletion are possible. The mahseers of India are reported to be declining rapidly. Lack of information on these species makes their ecostatus uncertain. This is further complicated by their distribution which is restricted geographically and appears rare at any one location.

The National Commission on Agriculture (1976) in its report on fisheries stated "...it has been reported that there has been a general decline in the mahseer fishery due to indiscriminate fishing of brood fish and juveniles and the adverse effects of our river valley projects", and recommended "extensive survey and detailed ecological and biological investigations".

The exact numerical assessments of the catches of mahseers are not available because of lack of species-wise statistics of inland fish landings. Whatever figures are available from a few isolated surveys as well as from observations of anglers and fishery biologists, indicate serious decline of the fishery. Dr. A. G. K. Menon (cited by Kulkarni, 1994) reports that the mussullah mahseer is almost extinct in the rivers and lakes of Peninsular India.

Causes for depletion

The main causes for depletion are the wanton killing of brood fish and juveniles and the deteriorating ecological conditions of the spawning and feeding grounds. It is well known that mahseers migrate upstream into shallow running waters for spawning. At this time, unscrupulous fishermen can easily kill the brood fish with sticks, swords, spears and other implements, as the gravid fish are heavy and slow in movement. Thus, many of them are done to death before they have a chance to spawn. Some of them which escape the onslaught, breed, but the resultant hatchlings and fingerlings after being victims of different types of predation, again fall prey to fisherman, when they are on their downstream march. The destructive methods of fishing could result in total loss of these fingerlings. The change in habitat or the ecological condition of the riverine system is another serious handicap faced by the fish. The numerous multipurpose dams have changed the ecology of the area and migratory fish such as mahseer can no longer ascend to streams.

Pollution caused by industrial and domestic effluents leads to deterioration in ecology which subsequently places stress on the fish resulting in their reduced ability to survive and propagate.

Need for conservation

In respect of sports fish like mahseer, where quantitative data in regular sequence is not available for comparison, it is dangerous to wait for conclusive proof of depletion. One may then unknowingly reach the point of no return when it could be too late to mend matters. It is necesary, therefore, to analyse the situation objectively from the information available and chalk out a strategy for conservation and continued propagation of the mahseer which appears to be really endangered. It is essential to prevent the brood fish and juveniles from destructive killing by fishermen and resort to artificial propagation and ranching. These measures will save the species from extinction and consequent loss of valuable genetic material.

Present conservation efforts

Natural replenishment of mahseer stocks has been impeded by low fecundity, long hatching period and semi-quiescent stage and extreme vulnerability of early larval stages to predation.

The hatching period of *Tor khudree* is 60 to 80 hours even in higher water temperatures of 24°-28° C, compared 18 hours of catla, rohu, etc. Further, semi-quiescent period is 6 days for *T. khudree* compared to 3 days for catla, rohu, etc. In this stage mahseer hatchlings tend to remain at the bottom, huddled in large numbers in corners and crevices.

The heads remain tucked away from light and their tails keep vibrating constantly. In this condition, they are highly vulnerable to all kinds of predators. During this critical period heavy mortality occurs. Dr. Kulkarni and Ogale have largely overcome this handicap by artificially breeding *T. khudree* at the Lonavala Farm of Tata Hydroelectric company and distributing fry/fingerlings for stocking into natural waters. For this purpose a system of catching ripe brood fish from the lake, stripping them manually and fertilizing them using milt similarly obtained has been adopted. The eggs thus fertilized are hatched in the hatchery and reared to fry stage of 30-35 mm. A technological advance has also been made in transporting fertilized eggs to distant destinations by means of air, keeping them in moist cotton. Nandeesha *et al.* (1993) have been successful in induced breeding of farm reared mahseer at Harangi Fish Farm in Kodagu district and the resultant fingerlings have been released into the Harangi river. Further work on the standadization of breeding of farm raised *T. khudree* is in progress.

Mahseers are omnivores, feeding on a wide spectrum of food viz., small shrimp, crustaceans, molluscs, insect lavcae, eggs, paddy grains and various seeds. For successful ranching, seeds have to be reared to fingerling stage. Since they grow very slowly, efforts have been made at the College of Fisheries, Mangalore, to enhance the growth of mahseer seed throught artificial diets, under an ICAR sponsored scheme. A systematic study to evaluate the optimum protein requirement was carried out, employing casein based pelleted feed, containing graded levels (35-50%) of protein. Fish fed at 5% body weight recorded the best growth and food conversion with the diet containing 40% protein at the end of the 135-day experiment. Wet diets were found to be used more efficiently by mahseer fingerlings compared to dry diets. De-oiled silkworm pupae as a source of protein gave the best results, followed by fish meal. Prawn waste and *subabul* powder as a source of protein were found to be inferior. Among the hormones used to enhance the growth of mahseer fingerlings, HCG alone or in combination with DES and 17a-MT induced higher growth, DES + HCG producing the best growth, feed conversion and feed utilization. Incorporation of sardine oil as a source of lipid was found to have sparing action on protein. Digestive physiology of various life stages of *T. khudree* fed on natural and artificial diets has also been studied under another ICAR funded research scheme, at the College of Fisheries. Further, cryopreservation of *T. khudree* milt is being standardized as part of a study funded by the International Foundation for Science, Sweden.

Efforts are being made by the Department of Fisheries, Government of Karnataka; Wild Life Association of South India (WLASI), Bangalore; and Coorg Wild Life Society (CWLS), Kodagu, to rehabilitate the Deccan mahseer *T. khudree*. The Department of Fishries has stocked a few sanctuaries with about 1,50,000 fingerlings obtained from the Tata Hydroelectric Company, Lonavala. Fish Farmers Development Agency, Yadavagiri, Mysore has also released about 30,000 of the mahseer young ones in river Kavery. The WLASI, Bangalore, has taken on lease a stretch of about 20 km. of river Kavery from the Department of Fisheries two decades ago and has stocked about a lakh fingerlings of *T. Khudree* for replenishing the mahseer stocks. This stretch of river is about 80 km from Bangalore. The Association has also arranged for watch and ward of the above stretch of river for protecting the fishery. The WLASI is also providing sport fishing facility for anglers in this stretch of river during the fishing season from October to May. The anglers obtain license from the Association by paying a prescribed fee. They have to execute an indemnity bond binding themselves to undertake to fish only with rod and line. When they catch mahseer, regardless of their weight, the anglers have to unhook the fish carefully and release back into the river, after recording morphometric features. The anglers are provided with approved guides of the association. Catches of mahseer during each season are recorded and census is maintained. The CWLS, Kodagu is another voluntary organization which is engaged in protecting mahseer. The Society has taken on lease a stretch of 28 km of river Kavery from Siddapura bridge to Guddenhosur in Kodagu district. They have been stocking young ones of mahseer in this stretch of river since 1993. They also organise sport fishing in this stretch of river and maintain catch statistics. The anglers are governed by similar rule followed by the WLASI.

Action plan for conservation

Concerted efforts are needed if we have to revive the stocks of this majestic fish and save it from extinction. The action plan for conservation should include measures like establishment of more sanctuaries, prevention of destructive methods of killing, artificial propagation and ranching and improvement of habitat.

Mahseer being a voracious, non-shy feeder, is capable of getting accustomed to artificial diets. This makes establishment of sanctuaries easier with the participation of people. Sanctuaries serve the useful purpose of protecting mahseer in fair weather, but being in open course of rivers, the movement of fish is not restricted when the rivers are in spate. The gravid fish leave the sanctuaries by instinct and migrate to shallow streams for spawing. At this time they are exposed to the usual onslaught of illegal poachers and even when they breed, eggs are sometimes affected by natural constraints. Thus, though the sanctuaries

protect the fish in fair weather, during flooded conditions or breeding season, they are not protected and hence the survival of young ones suffers, resulting in very low recruitment. Supplementary methods of conservation, and rehabilitation of mahseers, therefore, have to be considered.

Increasing human interference is unavoidable in any developing economy. Prosperity of people is linked with the construction of dams which affect the habitat of mahseer. Effective prevention of pollution is almost impossible. Under these circumstances, the only other methods of conservation of this species are propagation through stocking of perennial waters with larger seed and observation of conservation rules, such as enforcement of Fisheries Act. The conservation efforts have to be three pronged. 1) Stricter enforcement of fishery rules to prevent illegal methods of fishing, such as, use of explosives, in all seasons. 2) Prevention of killing of brood fish and juveniles during the breeding run. 3) Identification of natural spawning grounds and their protection from poachers and pollution and 4) Replenishment of stock by artificial propagation.

Over-exploitation of fishery waters and indiscriminate fishing of mahseer need to be stopped for ensuring their recovery and sustained production. The protective legislation which includes prohibition of destructive fishing methods, observing closed season, regulation of mesh size, limit on catches, restriction of fishing effort and declaration of sanctuaries need to be enforced more vigourously. Participation of local people in the conservation effort is most essential to achieve success. Hence first priority should be given to educating people on the importance of conservation of mahseer.

Replenishment of stock can be achieved by artificial propagation, which includes, induced spawning, rearing of fry and fingerlings and ranching in numbers sufficient to revive the natural stocks to a level at which they can propagate naturally, without the fear of extinction. In this effort reservoirs should be taken advantage of as they are not only a source of water, but also serve as a habitat for mahseer. Catches from Bhadra reservoir indicate excellent growth of mahseer in this habitat. The following steps are suggested for the revival of mahseer.

1. A fish farm should be established in close proximity of every new dam as also some of the existing dams.
2. Mahseer raised in the farms should be artificially bred and seed reared to advanced fingerling stage using artificial diets.
3. The fingerlings should be released into reservoirs as well as down stream waters as a rehabilitation measure.

Rehabilitation of mahseer has to be undertaken as an obligation arising out of the change of ecosystem on account of construction of dams. This has to be funded by the authorities concerned as a compensatory measure. No total ban is proposed on mahseer fishing, but if the above steps are taken and monitoring kept up, the mahseer can be conserved to preserve biodiversity.

References

Kulkarni, C. V., 1971. Spawing habits, eggs and early development of Deccan Mahseer, *Tor khudree* (Sykes). *J. Bombay Nat. Hist. Soc.* 67: 510-521.

Rainboth, W. J., 1990. Cyprinid fishes of Southeast Asia. In: I. Winfield and J. Nelson (Eds.), The Biology of Cyprinid Fishes, Chapman Hall, Inc.

Jayaram, K. C., 1994. Status of the Deccan mahseers: an appraisal, In: Nuatiyal, P., Mahseer, The Game Fish, Rachana, Srinagar, C-23 - C-39 pp.

Fish Biodiversity Of Western Ghats And Coastal Zones

K. V. Radhakrishnan and K. Chandramohan
Department of Fisheries Resources and
Management College of Fisheries, Mangalore - 575 002.

Biodiversity indicates the ecological array in the distribution of species in space which is invariably an index of its biological success and adaptive radiation. Western Ghat zones are especially noteworthy for their broad fertile spectrum of flora and fauna, against the back drop of well-wooded areas, and unspoiled coast line with positive productive freshwater lines. From the fish faunistic view point, both freshwater and marine, the potentials are rather very large with wide varieties of fin fish and shell fish species some being specific to the region. These water tracts are perhaps least exploited regions though unquestionably more productive.

Coastal Karnataka and Malnad areas along the West Coast belt are richest in fishery resources experiencing a very heavy and reliable rain fall with good sea borne trade through major ports and with all infrastructure facilities of a pulsating trade center. All the riverine systems of Western Ghat sector share some collective features on species distribution pattern and abundance with more or less comparable hydrobiological and soil characteristics besides the ecosystem features. Hence a general line of thought can well be drawn as for fresh water fish biodiversities and marine continental shelf fisheries along west coast zone.

Study of freshwater fishes of Western Ghats starts with Day's, endeavor on Ichthyology. The Western Ghat fish were subsequently dealt with by Pillay (1929), John (1936), Silas (1951), Hora (1942), Mukerjee (1931), Rajan (1955) and Ramadevi and Indira (1986) and an excellent threatise on the fishing resources detailed by Jhingran (1991).

Essa and Shaji (1997) in their studies in the Nilgiris biosphere during 1993 found that the reserve comprises important locale in reflecting the rich fish diversity of Western Ghats. A total of 56 locations were surveyed and 92 species belonging to 24 families and 46 genera were collected during the survey. Among 92 species recorded 37 (42.22%) were endemic to Western Ghats of which 9 species were strictly endemic to fresh waters of Kerala.

Among the 92 species, 69.75% of total recorded from east flowing and 68 (73.91%)

from the west flowing rivers of Western Ghat zones, 24 (26.09%) species were in east flowing rivers and 23 (25%) in west flowing rivers 9 species (9.78%) were endemic to Kerala. The east flowing rivers were more diverse compared to west flowing ones. But the west flowing rivers had almost all species endemic to Kerala. East flowing rivers harboured a number of Western Ghat endemics, 27 out of 37, and as against west flowing which had only 24. Of these, 10 species were found only in east flowing and 9 in west flowing rivers. *Labeo potail, Danio (Brachy donio) rerio, Noemacheilus petrubanarescui, N. nilgiriensis, Osteochilus brevidorsalis* and *Schismatogobius deraniyagalai* are new addition to freshwater of Kerala. (08.70% of the total). *Cyprinus carpio cummunis, Poecilia reticulata, Tilapia mossambica* are exotic species to Kerala and were thriving better than native species. *Labio rohita,* endemic to North India and introduced to South, also thrived well and supported the fisheries of Waynad.

Among riverine system, Kabani was more diverse with 59 spp., followed by Chaliyar with 50 spp. while Kunti river harboured only 11 species.

Ecological strategy:

Fish forms an effective link in the conversion of primary production to secondary. carnivorous feeds. Herbivorous fish close to producers are better converters of energy with short food chain unlike carnivorous with long food chain. Freshwater ecology of Western Ghats are abound with rich and diverse fish and shell fish species invariably under exploited. Being rich animal protein source it is an ideal resource to combat the malnutrition of teeming millions. More employment avenues can be opened for rural poor along Western Ghats, making use of unskilled labour in capture as well as culture avenues. These ventures which are highly viable and operable can give the much required social thrust and upliftment to rural poor which is indeed the crying need of the hour. The aquaculture ecosystem manipulation and control with a judicial management strategy is the right step urgently required in this context.

The innumerable fresh water ecosystem potentials in the form of ponds, tanks, lakes, reservoirs irrigation canals and rivers in this agrarian oriented Western Ghat Zones are in fact under utilized to a great extent from the fisheries biodiversity view point. What is required now is a strategy to bring out the full species potential available, their distribution and abundance through a suitable stratified sampling design and propose a plan of exploitation and management in order to obtain maximum sustained yield from these water bodies and bring about an effective conservation measures.

Coastal zone prospects in marine sector along Western Ghats are mostly concentrated in shallow inshore belts and estuaries. The continental shelf extending to about 200 M support great array of marine species not rationally exploited. The Western Ghat coastal zones are

rich in Bombay duck (Northwest) Pomfrets, Sciaenids, Polynemids, other perchs, eels, cat fishes, clupids etc. Besides a commendable population of shell fish fisheries these latter also are abound in many estuarine stretches of plentiful river system of Western Ghat zones forming a very sound basis for rural fisheries. Besides the pelagic fisheries like mackerel, sardines, tuna, silver bellies etc. are found a plenty along this zone. The lack of diversity in coastal capture fisheries is the main draw back. Sea food industry being highly institutionalized along prawn resources. Thus leaving aside other species compositions of the sea, to have a proper diversification in resource utilization along marine coast and estuarine belts as well is urgently needed. Non conventional resources of Western Ghat coastal zones like sea weeds, corals, sponges, marine turtles and sea mammals need to be carefully managed since many are coming in the Red Data Book. Suitable strategies are to be drawn along side to protect, preserve and conserve all these multi species wealth of western coastal zones.

Legislation and regulations

Parallel to conservation and development of fresh/ marine water fish biodiversity, certain regulatory measures are required in their exploitation. Many states, though having regulatory laws on paper, do not enforce the same or sparingly do so without any practical impaot. There are many instances of unregulated tribal, traditional and small scale local fisheries in operation.

Regulatory measures may be in the form of direct or indirect control on fishermen. The former revolves around legistrations and the latter the manipulation of economic forces for fishery regulations. Certain direct methods deal with leasing/licensing and mesh size regulations, declared closed seasons and declaration of sanctuaries for protection of spawners etc. All these can be effectively implemented through common measures and regulations.

References :

Easa, P. S., and Shaji, C. P., 1997. Current Science, 73, (2): 180-182.

Hora, S.L., 1942 .Rec. Ind. Mus., 44: 193-200.

Jhingran, V. G.1991. Fish and fisheries of India, Hindustan publishing Corporation (India) Delhi, pp. 729.

John, C.C., 1936 J., Bombay Nat. Hist. Soc. 38: 702-733.

Mukerji, D. D., 1931. J. Bombay Nat. Hist. Soc. 35:162-171.

Pillay, R. S. N.1929. J. Bombay Nat. Hist. Soc. 33:347-379.

Rajan, S. 1955. J. Bombay Nat. Hist. Soc. 53: 44-48.

Rema Devi, K. and Indra, T. J. 1986. Rec. Zool. Surv. India. 84: 243-257.

Silas, E. G. 1950. J. Bombay Nat. Hist. Soc.48: 792-797.

Bird Diversity Of Western Ghats Environs Of Karnataka

Pramod, P,
Biodiversity Unit, Jawaharlal Nehru Centre for Advanced Scientific Research,
Jakkur P. O., Bangalore 560064.

One potential question of great concern for ecologists is, why some areas are more diverse than the others. Many factors come forward as the reasons to it. Some of them are abundance in food (Martin 1987), availability (Holmes 1990, Karr et_al 1992), in some cases continued availability of habitat/heterogenity and availability of water and so on. But the more striking problem is that, in each case the prime factor is observed to be different. Many of these factors may complementarily contribute to it. Here this study do not go rigorously into the factors affecting the distribution. But by looking directly at the overall distribution of bird diversity and it's changes across the area and the habitat in seven localities, it tries to find out general rule which governs such patterns. It also gives broader patterns of land bird communities of Western Ghats environs of Karnataka state.

Study area and Methods

Study localities were seven centres located in the Western Ghats parts of Karnataka State (figure 1). All of them were the forested villages closer to the following townships namely Sirsi, Kumta, Sringeri, Badravathi, Karkala, Subrahmanya and Makuta in the order of decreasing latitude. Among these, Badravathi and Sirsi are of more deciduous biotope, Makuta, Karkala, and Sringeri of more evergreen formation and Subrahmanya and Kumta of mixed semievergreen formation. All the studies except Makuta is a village landscape with considerable extent of forest. Makuta study site is in more or less homogeneous evergreen forest.

The method adopted for the sampling is simple fixed width line transect (Verner 1985), where the observer walks through the line of a fixed length in a specified time and records all the birds observed in between the fixed boundaries on either side for the reliable identification. The length of the transect was 500 meters and boundaries 50 metres on either side of the transect.

One transect cut through only one kind of habitat. In each locality many such habitats were sampled giving representation to the overall landscape heterogenity. The study conducted during the period between October 1995 to February 1996. All the observations were made in the morning hours between 6.30 am to 10.30 am.

Result and Discussion

Data: Fortynine transects were conducted in seven localities which are distributed in ten habitats. Total number of species observed in these 49 transects are 158. Table 1 gives further details about them.

Alpha Diversity: Among the localities studied, Bhadravati showed maximum species richness in overall accumulation and in rarifraction to the smallest number (Table 1). Diversity both in overall richness and accumulated richness may be due to sample size bias also, but expected to be low compared to the more heterogenous landscape. Mean number of species and individual birds observed per trasect varies in a different manner. Sringeri, one of the most diverse sites in terms of rarified species richness, is on the lower side where as Subrahmanya is the highest with very little standard deviation. A comparison between Karkala and Kumta gives more information. Though the number of individual species which is observed in the transect is low in Kumta, total number of species observed and the mean number of species per transect is high. On an average one species is observed in 13.7 transect out of 49 (ubiquity). The evenness of species abundance is highest in Sirsi followed by Kumta, Sringeri and Karkala (fig.2). A summary statistics of eight community attributes per transect for all the localities pooled together is given in Table 2.

Beta Diversity: Turnover of the species between the habitats will give a picture of diversity distribution and pattern in any given landscape. Here transects of different habitats compared using Jaccard's similarity index for the pairwise similarity of the habitats. Figure 3 shows clustering of habitat on the basis of similarity in species association. The natural habitats distinctly form a cluster with the similarities ranging from 40 to 45 percent. Among the Manmade habitats all plantations form a cluster which clearly shows its differences with the birds of habitations and paddy fields which by itself forms a seperate cluster. On an average, any two habitats share ten percent species. This clearly indicates that the kind of habitat dictates the presence or absence of species in an area. Therefore composition of habitats in the overall landscape is all the more important.

Conclusion

In this study, habitat type is found to be one of the most significant factor in determining

the diversity of species in any given area. And more complex landscape structure with different habitat types brings more bird species into co-existence.

Acknowledgement

This work has been financially supported by Ministry of Environment and Forest and the PEW Foundation. The support provided by the members of the Western Ghats Biodiversity Network and the State Forest Department is gratefully acknowledged.

References

Holmes R. T. 1990. Food resource availability and use in forest bird communities. A comparative view and critique. In biogeography and ecology of forest bird communities Ed. A. Keast. pp. 837-893.

Kar J. R., M. Dionne, I. J. Scholsser, 1992. Bottom-up vs. topdown regulation of vertebrate populations: Lessons from birds and fishes. In effects of resource distribution on animal plant interactions. Academic Pres Inc. 243-286.

Martin T. E. 1987. Food as a limit on breeding birds: a life history perspective. Ann. Rev. Ecol. Syst. 19: 453-487.

Verner J. 1985. Assessment of counting technique. In Current Ornithology. New York 2: 247-302.

Figure 1 : SAMPLING LOCALITIES

Table-1 : Diversity of different sites.

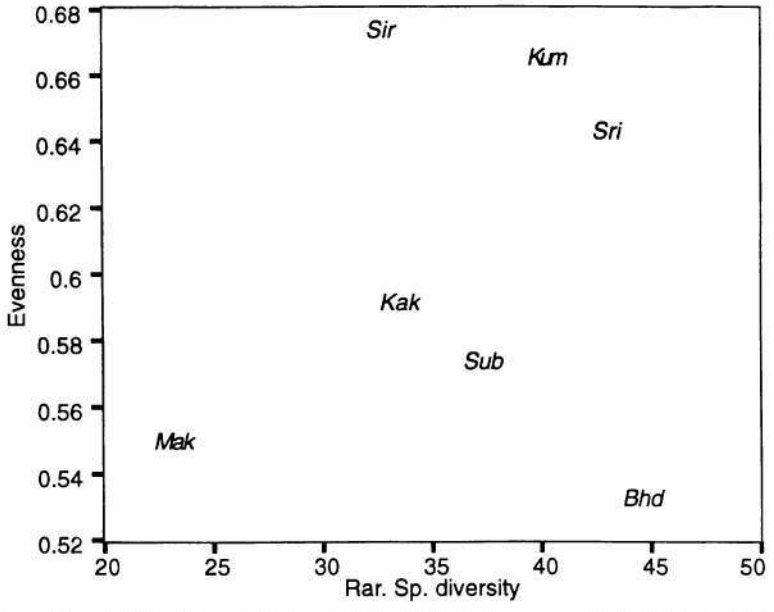
Locality	NoTr	NoHbt	NoSp	NoInd	Rar. Sp	MnSp/Tr	Std	MnInd/Tr	Std
Sringeri	11	5	82	628	44.25	15.73	7 12	57.09	15.73
Bhadravati	15	7	106	1544	45.52	21.53	6.59	102.93	74.68
Kumta	7	5	66	364	41.55	16.86	5.1	52	16.37
Sirsı	3	3	36	149	33.45	16.67	2.87	49.67	23.44
Karkala	5	3	51	384	33.97	18.6	5.2	76.8	21.6
Subrahmanya	6	3	62	703	37.87	24.83	1.86	117.17	24.02
Makuta	2	1	23	117	23	16	3	58.5	17.5

Table-2 : Details of eight transect level community attributes.

Attributes	Mean	Std	Max	Min	C V	Median
No. Individuals	80.7755	53.2427	259.0000	17.0000	0.6591	72.0000
No. Species	19.1429	6.5027	36.0000	6.0000	0.3397	19.0000
Rar. Sp. Richness	9.5383	1.3716	12.5925	5.8333	0.1438	9.7075
Exponential of Shannon Index	12.1993	3.7123	20.0927	4.2295	0.3043	11.4218
Simpson Index	8.7962	2.9468	16.9535	3.3750	0.3350	8.7628
Fisher's Alpha	9.0013	3.2016	21.0011	3.1516	0.3557	8.9239
Evenness	0.6900	0.0909	0.8875	0.4815	0.1318	0.6921
Mean Ubiquity of all species/tr	13 7062	2.6344	19.4286	6.3889	0.1922	13.8235

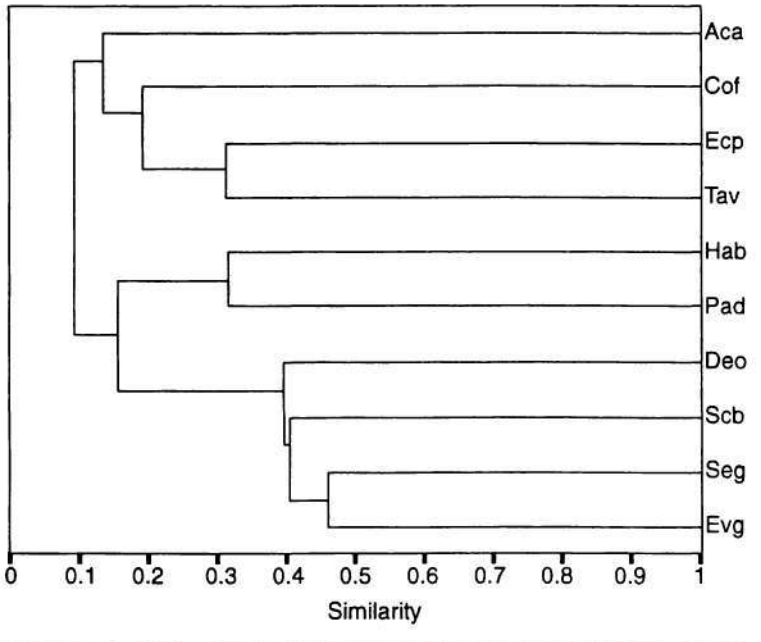
Alpha Diversity

Rar. Sp. diversity Vs Evenness



Sir = Sirsi; Kum = Kumta; Sri = Sringeri; Kak = Karkala; Sub = Subramanya; Mak = Makuta; Bhd = Bhadravati

Beta Diversity of Habitats



An Overview Of Spices Plantations In Western Ghat Environments In India

V. S. Korikanthimath and P. Rajeev
Indian Institute of Spices Research, Regional station,
Appangala, Madikeri, Karnataka

Introduction

India is the land of spices. Spices like black pepper and small cardamom have originated in the Western Ghat region of South India. The Western Ghat region is known for its rich biodiversity where farming/cropping diversity and environmental diversity are inexplicably linked. This is exemplified by wide spatial and temporal variation in climate and ecology. It may not be wrong to say that the spice heritage of the region has profoundly influenced the cultural and historical evolution of the country.

The ghat system covering three states viz. Kerala, Karnataka and Tamil Nadu is ideally suited for the cultivation of a variety of spices and aromatic crops. India being the major producer of spices, ranks first in terms of area and production of black pepper, ginger and turmeric.

A wide variety of spice produced is being domestically consumed as well as exported. In addition to the black pepper of commerce (dried berries), pepper is also traded as white pepper, canned green pepper and pepper powder. Cardamom is marketed as dried capsules. Ginger is traded as dry ginger, raw ginger, ginger flakes, ginger in brine, bleached dry ginger etc. Polished rhizomes of turmeric is the product of commerce. Cinnamon is marketed as processed bark, whereas immature dried bud of clove is the traditional clove of commerce. In addition to the above commodities, value added products such as oleoresin and oil from all these spices are important items in market. These products which fetch us crucial foreign exchange amply signify the importance of plantation economy of Western Ghat.

This paper tries to analyse the following:

a) History of spice cultivation and its varietal status
b) Status of spice industry in terms of production, yield and exports
c) Some sensitive shifts in response to market forces that would govern the industry and future managerial thrusts.

a) Historical perspective and varietal status

Black pepper and small cardamom have originated in the tropical evergreen forests of Western Ghats. Domestication of black pepper might have strated about 6000 years back, presumably from wild state. Presently over 100 black pepper cultivars are produced in the country which includes not less than 10 bred varieties. Cultivation of cardamom had begun in very ancient times when it was collected as forest produce. Today three taxonomic varieties, namely, Malabar, Mysore and Vazhukka are recognized for commercial cultivation. Till 1980 India was the leading producer of cardamom. Today the central American country Guatemala is leading both in production and export of cardamom. During 1994-95, an all time record production of 700 MT of cardamom was exported from India. However production fluctuation and stagnant productivity had been the common features of the sector as influenced by drught, flood and incidence of many viral diseases.

In ginger and turmeric, about 50 cultivars each are identified which were domesticated from ancient times. Ginger is cultivated in about 65,000 ha while turmeric in 1,45,000 ha out of which a huge proporation occupies Kerala, Karnataka and Tamil Nadu states. Even though conditions are ideal, India is not self sufficient in the requirements of tree spices produce like nutmeg, clove, cinnamon, cassia and pimento as these commodities are presently being imported. Another important crop worth mentioning is vanilla. Eventhough domestication of vanilla started about a 100 years back, commercial cultivation is yet to pick up in the country.

It is a fact that systematic research followed up with extension efforts have helped the popularization of many improved varieties of spice crops and *ex situ* conservation of many endangered wild spice species. Collection, conservation and cataloguing of germplasm of spice crops followed by scientific methods and biotechnological approaches have been the thrust areas of research in various research stations. Through these efforts 10 high yielding variety of pepper, 7 cardamom, 2 cinnamon, 5 ginger and 16 in turmeric have been released for cultivation (see Table 1).

b) Trends in production, productivity and export of spices

The economics of spice production and marketing is recently undergoing rapid shifts. Thus the plantation economy is presently passing through a phase of tough competition from producers elsewhere. For instance India was the major producer and exporter of cardamom till a decade back. Since 1980, the Central American country Guatemala has made strong inroads into cardamom production and trade. As of now 90% of world export

is from Guatemala. Similarly Indian pepper is facing tough competition from Brazil and Indonasia. This section attempts a critical analysis of trends in production and market of spices commodities before understanding the response of the industry to competitive market forces and global challenges.

Table 2 reveals the details of area, production and yield of major spices grown in India. The area and production of black pepper have considerably increased over a span of 25 years (1970-1995). But the corresponding increase in productivity is only 24%. In the case of cardamom the production and productivity have registered an increase, in spite of a decrease in area. But the productivity level is still far below the potential yield of the crop. The ginger area and production in traditional tracts (Kerala and Karnataka) have increased considerably. Similarly an increasing trend in area and production of turmeric is well pronounced. The statistics regarding clove, one of the miner spices grown is also revealing an unhealthy trend. Even though there has been an increase in area of clove in both in Kerala and Tamil Nadu, there is no proportionate increase in production. On the other hand a marginal increase in production is reported from Karnataka in spite of a decline in area. To conclude, low productivity seems to be the major constraint of plantation economy in Western Ghats. This is especially so in the case of the major spices viz. pepper and cardamom. There is an immense scope for the promotion of many minor spices like clove, nutmeg and vanilla. Cultivation of ginger and turmeric can be expanded to non traditional areas as these crops can withstand wider variations in climate.

Much of the spice crops/commodities are consumed domestically. About 45 % of black pepper produced is exported. But only 10% of small cardamom, ginger and turmeric are exported. Export of spices contributed 6.72%-8.62% of the total export earnings of agricultural commodities. The spices export in the country has increased from 45653 MT in 1960 to 17,5532 MT in 1995. The details are furnished in Table 3. Considering the overall export scenario the picture is not as rosy as it was. With the recent globalisation of economy in many developing nations there are many new entrants into the world market. Comparatively higher productivity and low cost of cultivation have enabled other countries to outbid India in the international market.

c) Emerging Spices based Cropping systems - Tracking change

Multiple Cropping

As mentioned earlier, the spices economy in the world over is undergoing rapid shifts. India has been pushed down in case of cardamom exports. Similarly the price of pepper

is being increasingly influenced by production and price status in other countries like Brazil and Indonasia, with the result that farm level prediction of prices turns out to be difficult. The immediate response of the growers to these competitive market forces has been crop diversification. Spices based multistoried cropping systems are fast emerging in the Western Ghat region.

Though the prime motive for diversification seems to be profit and economic risk aversion, the emerging cropping systems symbolise a higher degree of ecological sustainability. Multiple cropping systems better utilise the limited dimensions of time, space and resources. There is an increased awareness about the improved cultivation practices that would boost the productivity. Following are the major cropping systems in Western Ghats.

- Coffee intercropped with cardamom and pepper on shade trees.
- Arecanut intercropped with cardamom in higher elevation often mixed with banana in the lower elevations.
- Coconut intercropped with cardamom.
- Coffee intercropped with medicinal and aromatic crops.
- Coffee mixed with mandarin orange, cardamom and pepper.

Future Challenges

Multispecies cropping systems maximise landscape/species diversity. However the constraints in a multiple cropping system are more difficult to be identified than in a mono cropping system. Multiple tree-crop interactions and multiple activities are involved in the farm. But such complexity is always associated with diversity.

When we think in terms of intensification of the plantation economy, we should also be equally concerned with the preservation of a natural eco-system that would support a viable and eco-friendly production system. According to one school of thought, disturbances in the forest ecosystem and the consequent ill effects is one of the major reasons for the low and stagnant productivity of cardamom. Paradigms of natural resource management should be evolved with the objectives to maximise diversity, minimise pollution and losses, sustain farm income and generate employment. This would mean a more eco-friendly farming system based on a farming systems perspective. It has been demonstrated over long term operation that production costs can be reduced by more than one third by using less fertilisers (down by 35%) and with fungicide and pesticide inputs reduced by 79%. Management of

intergrated systems requires integrated nutrient management (soil amelioration, reduced use of external inputs, organic farming through organic product recycling, micronutrient management).

Conclusion

Development of Indian spice industry is at cross roads. The domestic industry has quickly responded to market risks and challenges by resorting to crop diversification and adoption of improved cultivation practices. However the productivity of the major spice crops need to be increased further through an integrated, at the same time, eco-friendly farming practices. When we are faced with some expansion of cropped area in the Western Ghat region, we should equally be concerned with preservation of an ideal ecosystem that would support a viable spices economy.

Table-1 : Improved varieties/hybrids available in major spices

Spices	Variety/hybrid
Black Pepper	Panniyur-1, Panniyur-2, Panniyur-3, Panniyur-4, Panniyur-5, Sreekara, Subakara, Panchami, Pournami, Palode-2.
Cardamom(Small)	Mudigare-1, PV-1, CCS-1, ICRI-1, ICRI-2, ICRI-3, Mudigere -
Turmeric	CO-1, Krishna. Sugandham, BSR-1, Suvarna, Suroma, Sonia, Rajendra, Suguna, Sudarsana, Roma, Ranga, Rashmi, IISR Prabha, IISR Prathiba, Mega Turmeric, RCT-1
Ginger	Suprabha, Suruchi, Suravi, Himagiri, IISR Varada.
Cinnamon	IISR Navasree, IISR Nityasree, Konkan ten.

Source: Souvenir Indian Society for Plantation Crops, 1997.

Table-2 : Area, production and average yield of major spices during last 25 years (A=area in'000 ha: P=Production in'000 tonnes: Y=Yield in Kg/ha.)

Spice	1970-71			1994-95			%Increase (Base yr. 1970)		
	A	P	Y	A	P	Y	A	P	Y
Pepper	119.96	26.16	218.0	195.0	53.11	272.0	62.5	103.0	24.0
Cardamom	91.48	3.17	34.6	73/7	6.33	85.9	-19.4	99.6	148/3
Ginger(Dry)	21.59	29.29	1356	62.09	186.1	2997.2	187.6	535.0	121.0
Turmeric(dry)	80.5	150.6	1870.8	147	659.4	4485.7	82.6	337.8	139.8
Clove	-	-	-	-	-	-	-3.6*	-7.7*	-4.3*
Nutmeg & mace	-	-	-	-	-	-	-	-	-
Cinnamon	-	-	-	-	-	-	-	-	-

*base year 1980-81

Source: Directorate of Cocoa, Arecanut & Spices Development, Calicut/Spices Board, Cochin.

Table-3 : Export of spices from India (1960-1994)

Year	Quantity	Value (Rs. 1000)
1960-61	45653	163960
1961-62	63733	175203
1962-63	48340	133730
1963-64	51179	152793
1964-65	52855	165465
1965-66	62463	230544
1966-67	51714	278191
1967-68	52195	271702
1968-69	51880	250441
1969-70	43975	344798
1970-71	47906	388200
1971-72	67866	366047
1972-73	51662	305612
1973-74	62793	556052
1974-75	54306	625925
1975-76	61952	727248
1976-77	60957	759810
1977-78	81228	1418849
1978-79	104884	1549295
1979-80	114959	1550765
1980-81	92538	1170550
1981-82	68375	925101
1982-83	76117	928541
1983-84	85835	1116622
1984-85	89155	2090224
1985-86	74501	2825208
1986-87	82825	2819877
1987-88	74501	2980803
1988-89	82825	2748066
1989-90	70279	2757609
1990-91	99946	2386691
1991-92	142104	3809676
1992-93	126820	4094847
1993-94	175532	5401244

Source: Spices Board, Cochin, 1993

PEOPLE'S BIODIVERSITY REGISTER

A Pioneering Exercise at Mala Village Panchayat

Dr. K. P. ACHAR
Professor and Head of the Department of Zoology
& Advisor, Bhuvanendra Nature Club-India,
Sri Bhuvanendra College, Karkala-574 104, Karnataka.

Introduction

The human life has been influenced by biodiversity from time immemorial. Biodiversity - wild, semi natural and cultivated - is on the decline. So also is people's knowledge and concern about it. There is considerable knowledge about biodiversity in a small section of the village community who are directly dependent on it. Unfortunately, the worth of their knowledge, as an intellectual resource, is not fully realized by the holders and seldom used by the management. Hence it is losing respect in the society only to be lost for ever or pirated at throwaway prices. Loss of traditional knowledge and practices of sustainable utilization of biodiversity is also an equally serious concern. Besides getting depleted, biodiversity is losing its importance in the world view of the village as a whole. For, its direct contribution to enhance the quality of human life is decreasing due to uniformed pursuit of ecologically unsound alternatives.

People's Biodiversity Registers or Panchayat Biodiversity Registers (or PBRs) are indeed records of folk knowledge and practices of conservation and uses - sustainable or otherwise - of local bioresources. These recordings of public domain knowledge serves the purpose of benefit sharing as envisaged in the Convention on Biological Diversity (CBD). The CBD accepts the sovereign rights of countries of origin over their biodiversity resources. These registers, therefore, also form an appropriate instrument for generating a significantly large missing component of our understanding for designing conservation efforts.

Mala village of Karkala Taluk in Karnataka State, located at the foothills of Western Ghats abutting the Kudremukh National Park, is one of the pioneer villages of Indian subcontinent to take up the PBR preparation for enlisting the knowledge of the use of nature's living resources from men and women of various religions, communities, castes and tribes.

The precious knowledge of different user groups and knowledgeable individuals is confirmed or otherwise through *grama sabha* and group discussions constitutes the hallmark of PBR concept.

Mala PBR has assumed greater significance as it is the first of its kind in India. After its dedication to the people of Mala *Village Panchayat*, it has been kept and maintained Grama Panchayat Office and made available to the public use and reference. This maiden exercise has certainly highlighted the dire need to move towards a multisectoral, locality specific, adaptive and pro-people management of biodiversity.

Now, it is earnestly hoped that the People's Biodiversity Register would soon be accepted by the State and Central Governments as a tool for participatory, decentralized and sustainable development, since it is an appropriate instrument for implementation of provisions of International Convention on Biological Diversity and Agenda 21 of the Rio summit.

Methodology

Srustigyaan is a methodology manual that we followed for documenting people's priorities for biodiversity conservation at the village level. This manual is a user friendly guide designed by Centre for Ecological Sciences of Indian Institute of Science and Foundation for Revitalization of Local Health Traditions (FRLHT) for assessing human-nature interactions.

Study tools and techniques followed during our study mainly included field surveys, individual and household interviews, group discussions for validation of recorded opinions and *Grama Sabha* for evolving a consensus conservation strategy.

Mapping was an integral component of our studies and the following maps were prepared : Habitation map was prepared with the participation of the local people depicting the location of temples, bastis, church, schools, bus-stops, buildings and many other landmarks. Landscape map was prepared based on the field surveys, incorporating various landscape patches. The local knowledgeable individuals also participated in this exercise. The Survey of India toposheet of the locality (Scale : 1 : 50,000) was used as reference for ascertaining the location of various landscape elements (Map 1, 2, and 3).

Research Agenda

The research agenda was divided into six major sequential topics. On each research agenda/topic, we tried to record the perceptions of different user groups separately, wherever required.

1. Peoplescape

Peoplescape includes the village profile, its environs, ethnic groups, their classification into user groups, knowledgeable individuals etc.

Village Profile: Mala Village is located on the foothills of Western Ghats, about 22Km. from the historic town of Karkala, in Dakshina Kannada District (Now, under the new Udupi District) of Karnataka State. The eastern boundary of the village merges with the Kudremukh National Park, notified in 1987. The total geogrphic area of the village is about 48 sq km (or 4,702 hectares) of which about 34 sq km (or 3,386 hectares) are on record as forested area. The altitudinal range varies from 100m in the foothills to about 1000m towards the hillcrests of the Western Ghats. The village has about 900 houses and over 5000 population inhabiting in four wards. The village has over 30 settlements, which fall under two prominent clusters-Heranjevallia and Yedapadivallia. The village has all the modern amentities.

Socio-cultural aspects: Mala is known for its ethnic diversity. The ethnic survey identified over 24 caste groups with *Bunts* occupying the dominant place (17.04%), followed by *Billavas* (15.26%) Scheduled Castes (11.48%) and *Chitpavan* Brahmins (8.62%). Among the Scheduled castes, *Mugera* (Mera) community is prominent, followed by *Nalkes* and *Paravas*. Among the Scheduled Tribes, *Marati Naika* is dominant followed by *Malekudiya Gowdas* and *Koragas*. As nomads, *Malekudiyas* were the shifting cultivators once upon a time, but now settled as agriculturists. Among the tribals, *Koragas* are considered to be the most backward. The upper socio-economic strata is represented by *Jains* and *Chitpavan* Brahmins. *Chitpavans* were immigrants who arrived three to four centuries ago from the neighbouring states of Maharashtra and Goa.

Mala has a number of Hindu temples including *Halepalli Sri Vishnumurthy* temple, *Sri Parashurama* temple at Yedapady, *Sri Brahmalingeshwara & Anjaneya* temples in *Chowki* and *Ubharyl Brahmalingeshwara* Temple and *Koteangadi Marigudi*. *Sri Adinatha, Sri Parshwanatha* and *Chandranatha Basadi's* at Koteangadi are the main Jain temples. The *Vimalamba* Church at *Chowki* is the only place of worship for Christians. Mala has no Mosque. There is a sacred grove called *Sri Brahmanatha* on the bank of Mullur stream.

The Tulu speaking people of Mala village have recorded their cultural history in different folk art forms such as *"Tulu Paddanas", "Tala Maddale"* and *"Yakshagana"* and *"Bhutharadhana"* (or Devil worship). From the view point of biodiversity, Bhutharadhane

is quite significant due to the importance assigned to plants and animals of the locality. *Bhutharadhane* artists decorate their bodies with different bioresources, besides using varied colours, costumes, ornaments made up of gold, silver, brass etc.

The plant material used in *Bhutharadhane* include mainly the tender leaves of coconut palm (Siri); sheathing leaf bases (*'pale'* or *'hale'*) and inflorescence (*pingara*) of arecanut palms; flowers of *Ixora coccinea* (*Kepula* or *Kiskara*), *Crossandra undulaefolia* (*Kanakambara* or *Abbalige*), Jasmine (*Mallige*) etc. In addition, bamboos, canes and parts of banana plants and coconut fibres are also used in this ritualistic form of art. The coconut leaves are used for making bows, arrows, spears, swords etc. *Bhutharadhana* rituals are popularly known as *'Kola'* which also means 'decoration'. *Bhuthas* are classified into male, female and animal categories. *Kalkuda, Koangethaya, Kotichennaya, Koraga-Taniya Gilirama* are the important male bhuthas. Female bhuthas include the incarnations (*avatharas*) of *Sri Durga,* such as *Duggalaya, Mahakali, Chamundi, Lekkesiri (Raktheshwari), Malarayee, Jumadi (Dhumavathi), Kallurti, Sathya devate, Ullalthi, Siri, Mayeendale, Korati* etc. The well known animal *bhuthas* include the *Panjurli* or *Varahi* (Pig or Wild boar), *Pili bhutha* or *Pilichamundi* (Tiger), *Mysandaya* or *Guliga* (Ox) etc. The actors of this intricate, ritualistic form of spirit worship (or *Bhutharadhana*) are, infact, the poor ecosystem people, *Harijanas,* mostly working as labourers in farms and plantations of upper strata people. Thus, *Tuluva* culture of Dakshina Kannada District is deep rooted in the Mala village also.

Biodiversity based Social Classes: We wished to know if different sections of the society differed in their conservation options and priorities. To study this we classified the village community into different usergroups. On the basis of their relationship with biodiversity, people were broadly divided into two categories:

1) Biodiversity user groups comprising of people with intimate interactions with biodiversity and (2) Non-biodiversity user groups consisting of people with least interactions with biodiversity. Biodiversity user groups are further classified into primary, secondary and tertiary ones depending on their degree of intimacy with the natur's and natural resources. Those who directly exploit/nurture's biodiversity are categorized under primary user groups. Those who process raw biodiversity materials or support its nurturing were regarded as secondary user groups. Those who consume biodiversity products and remotely related were grouped under tertiary user groups.

Primary user groups of biodiversity mainly included hunters, gatherers and labourers. They were further classified as NTFP collectors, medicinal herb collectors, honey and beeswax collectors, fishermen, firewood collectors, toddy tappers, forest plantation labourers, basket weavers, *gorabe* (*Kurambu*) makers, mat weavers, Non Timber Forest Produce (NTFP) traders, wood/timber sawers, lime makers etc.

Secondary user groups of biodiversity included the agriculturists and persons involved in Animal Husbandry. The bulk of the local people are small agriculturists who cultivate cereals like rice, oil seeds like sesam (*Sesamum indicum*) and pulses like blackgram, green gram and horse gram. Arecanut and coconut are the major plantation crops. In addition, pepper, cocoa and cashew were also cultivated. Rubber planters, Rubber tappers and sheet makers of Mala include mainly Christian immigrants from Kerala State. *Adike halethatte* makers of the village include a single *Chitpavan* family. Artisans mainly consist of carpenters, blacksmiths, silver smiths and goldsmiths mainly belonging to *Vishwakarma* community. Beedi rollers comprise mainly women and children belonging to different communities. Besides, there are copra traders. The watchers and gurads are the ground level forest personnel who monitor the vast stretches of reserve forests.

The Non-biodiversity user groups include people belonging to various socio-economic groups, such as the road labourers, potters, mudbrick makers, sand collectors, farm labourers, traders, school teachers, employees of aided and government institutions, masons, midwives, doctors, folk artists etc., who are all minor consumers of biodiversity based products. (Table-1).

Knowledgeable individuals. Knowledge is not uniformly distributed across individuals or communities in a population. We thus wished to know individuals recognized as more knowledgeable by majority of the people. Table 2 lists the knowledgeable individuals, their ethnicity and area of specialization.

2. Lifescape.

Lifescape includes various landscape/waterscape elements in the village and people's knowledge about species of plants and animals, especially focal groups. Biodiversity is not evenly distributed in different landscapes. Some patches have many species, others only a few. The species rich patches are not necessarily the ones with many rare and most utilized species. Similarly different usergroups may ascribe different conservation priorities to one patch and that one patch may vary from the other. So, we wished to know how different

components of biodiversity were distributed, utilized and needed conservation in different patches belonging to various habitat types. Further, we inquired which species deserved most conservation priority and where. This was possible on the basis of estimates of their population changes in different parts of the landsape.

Landscape: A landscape is a mosaic of patches belonging to various ecosystems, i.e., ecological habitat types (Forman and Godron, 1987). A typical Western Ghats low elevation landscape generally consists of several patches of evergreen forests, grasslands, water bodies, habitations, plantations, paddy fields, roads and so on. Each ecological type and sometimes even a patch may have its distinctive assemblage of species and is characterized by greater abundance of certain species. Mala landscape is comprised of two main domains, namely natural/semi-natural and manmade. In the natural domain two categories were identified, namely forests and non - forests. The waterscape of Mala is comprised of torrential hill streams and precipitous water falls. Important streams like Mullur, Heranje, Yedapadi etc., emerge from higher reaches of Western Ghats and join the main Kadari (or Machitte) hole', which flows in the south-west direction to join the river Yennehole', outside the village limits. Yennehole' as joins river Swarna, which after meandering across Karkala taluk, opens into the Arabian sea near Kallianpur in Udupi Taluk. The landscape composition of Mala is given in Table 3.

Plant diversity. The mala village environs harbour a great variety of plant species. Under the Western Ghats Biodiversity Inventorying Programme (Achar, 1996 b), we have sampled roughly half of the total plant diversity (flowering plants). These included 540 species belonging to 365 genera and 109 families of flowering plants, comprising of 193 tree species, 169 shrub species, 186 species of herbs (including grasses and sedges), 77 species of climbers/ lianas belonging to 55 genera and other 15 miscellaneous species. This accounted for only half the estimated species of flowering plants in just 25 sq km area of village catchment.

The range of domesticated plant diversity is by no means less impressive. These included rice, sugarcane, legumes, sesame, egg plant, citrus species, banana, mango, cashew, jamun, cinnamomum, cardamom, ginger, turmeric, pepper etc. Of the estimated thousand wild and cultivated species of flowering plants people have knowledge of about a third. Out of these, they prioritized 30 plant species, most of which are of great economic importance. Their abundance status and values ascribed by different user groups are listed in Table 4 . An average villager in Mala knows about 30 species of flowering plants. The NTFP collectors know about 60 to 100 species. The medicinal herb collectors know over 300 species. All category of people of Mala put together know about 350 species, including about 80 species of medicinal and some 22 NTFP plants.(Table 5) .

Animal diversity: The knowledge of animal species of Mala village is also equally impressive. Under the Environment Quality Monitoring Programme (Achar 1996 a), a total of 29 species of mammals, 84 species of birds and 20 species of inland fishes were recorded. Of these, people of Mala prioritized only 22 species, which included 10 mammals, 6 birds and 6 fishes. Their current status, preferred habitat and values ascribed to them by different user groups are listed in Table 6.

3. Ecological History

Before planning for conservation of biodiversity, it is necessary to understand the past and present process of its erosion and the driving forces behind the changes. The ecological history of Mala village could be traced back upto 300 years ago. Socio-political developments such as land reforms, declaration of protected area etc., provided useful benchmarks for caliberating the recent ecological history, as most people remembered those events well. The Land Reforms Act of 1974, the period of Indian Emergency (1975-'77) and the declaration of Kudremukh National Park in 1987 were remembered by all user groups.

The first phase of landscape changes might have been started by the *Malekudias* through shifting cultivation. The *Chitpavan* Brahmins probably immigrated to Dakshina Kannada District about 300-400 years ago (1600-1680 A.D.) from the neighbouring states of Maharashtra and Goa. They settled along the foothills of Western Ghats in Dakshina Kannada District, including Mala village. After settling down, *Chitpavans* must have cleared forest patches at the foothills of Western Ghats and started cultivating arecanut. Now they have become the expert horticulturists in Mala.

The ecological history prior to 1974 showed a community of various agrarian user groups with the rich land lords at the top and the insecure tenants and labourers at the bottom of the social hierarchy related to land use. Paddy was the prime agricultural crop, whose cultivation was confined mainly to plains of Mala village. On the foothills of Western Ghats, plantation crops such as arecanut, coconut, cashew, pepper etc., were cultivated. The tribal *Malekudias* were gatherers of minor forest produces including spices and honey. Fishing and practice of herbal medicine were also in vogue.

The implementation of Land Reforms Act of 1974 had a tremendous impact on agrarian relations throughout the district including Mala village. The landlords lost much of their agricultural lands, as a consequence, there has been an enormous increase in the number of marginal and small farmers and corresponding decrease in the large farmers.

Although it is rather difficult to estimate the biodiversity levels in the early phase of the ecological history dating back to 300 years or so, it may be safely estimated to be much higher. While *Chitpavan* Brahmins encroached on slope and riverain forests for arecanut plantations some 300 years ago, the Forest Department banned the shifting cultivation much later, which allowed some forest restoration. However, the need for revenue led to Forest Departmental and contractual plundring of the majestic evergreen forests for timber and plywood. Later the government gave some forest land on lease for cultivation and these got successively regularized through political pressures. This has resulted in the substantial encroachment of forest land for areca cultivation slowing down a bit. The Forest Department also imposed ban on clear felling as well as selective felling in reserve forests and subsequently the area was declared as part of the Kudremukh National Park. All these events favoured forest restoration. The possitive picture of the forest front is contrasted by the scrubs which are lost to arecanut and rubber cultivation during the last decade. Uncontrolled harvesting of cane over the years both by the locals and outsiders has practically led to the elimination of this vital NTFP from the nearby forests. Realising this ecologicl disaster, the authorities of the Kudremukh National Park have not only banned cane extraction, but also reintroduced the saplings wherever possible.

(Largesize *Adivasi* Multipurpose Production Society) LAMPS was started with a view to ensure fair price to the tribal collectors of NTFP and also to promote the extraction of NTFP sustainably.

Sri Brahmanatha, the sacred grove, on the bank of Mullur stream, spread over an area of about 15 hectare, remained unexploited since 300-400 years ago. Forest Department's ban on tree felling has been largely successful and also the afforestation programme. Afforestation programme pursued by the Forest Department has lessened the fuelwood pressure on natural patches of forests and benefited the ecosystem people to some extent. The cultivation of cane species in forest patches by the Forest Department might also improve the prospects of basket weavers and cane users of future generation.

4. Management Options

Management options include the options of the local people for managing the biodiversity in a sustainable and equitable manner. So far people were rarely given an opportunity to participate in making decisions relating to management of public lands and waters. Even the way they wish to manage their own holdings is entirely governed by the market or the powerful section of the society. So, mostly people tend to extract as much benefits from common property resources as possible without much concern for its sustenance. The attitude

so formed does not plan for better management of these natural resources. Thus, when we asked about their suggestions for sustainable usage and measures for protection of biodiversity, most villagers could not sketch a clear, holistic and multifaceted proposal. Hence during our studies people had to be convinced that they also might and in fact, should have decision making power. Besides, case specific questions had to be asked by promoting objective options for each aspect. After such preparation, people reacted with more interest and understanding.

The local NTFP collectors, mainly the tribal communities comprising of *Malekudiya Gowdas,* Marati *Naikas* and *Koragas* feel that a ban should be imposed on the collection of NTFPs by outsiders, who tend to overexploit in unsustainable manner by cutting branches and felling trees. People also reacted sharply against fish poisoning and exploding dynamite in fishing waters mainly by outsiders.

Crop raiding by wild boars is quite frequent and hence these are killed or traped by the affected farmers. Although cattle lifting is less frequent by pathers, they are often poisoned by the locals. In either case, people feel they must be adequately and urgently compensated for their economic losses to prevent the killing of these wild animals.

The tribal people are of the view that their rights to use the local bioresources from natural surroundings should be reserved. They plead that their very subsistence depends only on harvesting economic species from forests. They were not aspiring for legal property rights, but wish that they should not be disturbed from their present settings as it embodies their traditional way of living in harmony with nature for centuries.

It is the opinion of most user groups that the panchayat committee must be given the power as to what, where and when to protect, utilize or regulate the elements of biodiversity. The Panchayat committee can effectively monitor the trade of biodiversity if it gets some revenue from it for village development. According to a modest estimate, currently NTFP worth about Rs. 5 lakhs is being annually extracted from Mala Panchayat boundaries. It benefits the labourers, contractors, Forest Department, the LAMPS, but not the village as a whole, despite these being collected from public land. Even a moderate cess of 10% on total collection would generate precious funds for various village development schemes. Then, many other sections other than direct users can start taking interest in biodiversity conservation. Since only sustainable utilization of biodiversity would yield considerable annual revenue, most people might keep all around vigilance as an additional and opportunistic activity, as a part of normal life.

Of course, measuring and monitoring biodiversity of the village will be a difficult task. It is quite appropriate that knowledgeable people like local school teachers and students may be authorized and asked to assess whether the measure suggested by the decision making body are being implemented or not and whether the desired results are achieved or not. The teachers should be specially trained for this and they should also be provided with methodology manuals and field guides in local languages. In addition, the people opined that the *Grama Panchayat* must authorize the concerned teachers for measuring and monitoring local biodiversity. There should be credits and rewards for good ducumentation and if possible all this should be made as a part of the regular school curriculum.

5. Development Aspirations

Development aspirations include people's desire for progress in individual life and for the society and the likely impact to biodiversity. To understand the trade off between biodiversity and development we studied what social and individual development aspirations people have and how those might positively or negatively produce impact on biodiversity. We particularly asked people what changes in the existing policies would make various social sectors include biodiversity in their development planning.

Majority of the people have little concern for biodiversity. Only those who directly depend on it for survival and living with it are somewhat concerned. However, biodiversity conservation is not a high priority even in their future development plans. For, currently biodiversity provides little aid to raising standards of life, which is eveyone's pursuit. Clearly, civic amentities like water, road, school, health care, education are high on the priorities.

People are unaware that their common knowledge about biodiversity usage or the cultivars they have conserved might lead to patentable innovations and possibly channelize back part of the profits, which they can use for village development; or in case it is a personal unique knowledge, that the individual concerned might benefit.

The farmers wish to give up paddy cultivation and switch over to cash crops such as arecanut and coconut. Labour problems, escalation in the input costs and water management were some of the reasons they assign for this, with the result that there has been an increase in the area of cash crops including arecanut, coconut, rubber, cashew, cocoa and pepper. Besides, a number of user groups including horticulturists, fuelwood collectors, medicinal herb collectors, NTFP collectors, mat weavers and artisans aspire to harness wider spectrum of biodiversity for sustaining their economic activities. Such activities are bound to affect biodiversity adversely.

It is quite clear from the foregoing account that development currently ignores biodiversity. Today's restrictive conservation policies provide little economic benefits to grassroot people making them less interested. People would very much like that biodiversity brings them more money, help their development. This would further motivate them to conserve. Certain patches with low conservation value should be allowed for developmental activities including agricultural/ horticultural extension, construction of roads and dams and this would bound to benefit the ecological refugees such as migrant labourers. Calculated compromises between development and conservation would be in the best interest of all user groups.

6. Outer Links

The outer links deal with the perceptions of various kinds of outside individuals and agencies on the management options of the village. There are three Non-Governmental Organizations (NGOs) functioning in the Mala village:

(1) *Sri Kshetra Dharmasthala* Rural Development Project (SKDRDP) has introduced a novel scheme called "*Pragathibandhu*" which works on the basis of mutual labour exchange and thrift saving. It has been promoting ecodevelopment and also helping the people in growing crops like paddy, pulses, arecanut and coconut and in allied agricultural activities including dairy, sericulture and bee keeping. (2) The Dakshina Kannada *Zilla Parisarasakta Okkoota,* Guruvayanakere, is a pioneering organisation committed to saving the environment of the district and conserving the biodiversity of Western Ghats in particular. The monthly bulletin, *'Nisarga Loka'* published by the organisation, is dedicated to environmental education, conservation and development. (3) Dakshedte or Dakshina Kannada Social and Economic Development Trust Belvai, besides helping the people in housing schemes it also has afforestation scheme in its agenda. Although these NGOs have very little to offer for the conservation of biodiversity presently, they have succeeded in creating awareness against unsustainable exploitation of local bioresources. Their success may be attributed to the following key factors:

(a) Religious and cultural approach, (b) providing monetary assistance to the needy, (c) practice of participatory approach, (d) adopting reliable survey and monitoring methodology and (e) eliciting cooperation from various socioeconomic classes.

The villagers are, however, very much against those outsiders, who collect forest produce in a destructive way. The people dislike the way the contractors promoting illegal and unsustainable NTFP extraction and trade. There are no serious conflicts between the forest

department and the people as the officials are not imposing strict restrictions. Since, the people have been allowed legally or otherwise to access the natural wealth, they are not antagonistic to the government restrictions. The NGOs experiences have set a good example of reconciliation of various social conflicts and forging cooperation. It is worth emulating for biodiversity conservation as well.

STRATEGY AND ACTION PLAN

Feasible Conservation Strategy

With most social sectors losing interest in sustainable utilization of biodiversity, government or a handful of motivated individuals, NGOs, cannot meet the conservation challenges by themselves and that too in a monopolistic and exclusionary fashion. Social probelms are complex and many seldom have long term or complete solution. However, as a rule of the thumb, they could be addressed better by involving different interest groups, making them accountable to each other. Such a multi-sectorial governance should be built up from panchayat level upwards rather than with few agencies monopolising implementation of a top down or trickle down development model.

Any conservation strategy has to hinge upon elciting support of wider spectrum of the society. This is possible through a variety of policy interventions. Panchayats might be motivated to do so if they are permitted to charge some collection fees on the degree of conservation practiced. This may be monitored by teachers and students, besides government officials and NGOs. The educational system might be motivated to do so, through academic credits and cash incentives, besides social recognition. Making such first hand studies a part of the curriculum may be the only way to generate greater interests in the future generation. This would also help to forge the much needed exchange and synthesis of traditional and modern knowledge.

Of course, empowerment of local people and educational community should not be without proper awareness and accountability. This requires an annual stock taking of biodiversity, its usage, trade, knowledge and conservation. This should be properly mapped and described at length in the panchayat level registers. Schools and colleges might do a better documentation if it fetches them competitive awards. The Panchayats may well undertake it if it is made a prerequisite for annual development grants. The government departments currently in charge of these resources should further hasten and widen the scope of joint management programmes. Only then the whole society and not just a few officials, individuals or NGOs see biodiversity as a means to an end in achieving their personal and social aspirations would development

become biodiversity friendly by even sacrificing some of the choices through evaluation. The political will needed for this can be generated only through aforesaid "bottoms up" process of grassroot awakening, empowerment, accountability and commodification of biodiversity.

Policy Changes Required For Biodiversity Conservation

Current conservation policy focusses on a powerfu central guardian agency deciding on all areas and for all times. However, no one management scheme can be efficiently applied for large regions and long time periods. For landscape varies from place to place and from time to time. For instance, a complete ban on all tree felling might help restoration of the degraded forests; while it may turn people into anti-conservationists in areas with lots of trees. The decision on local protection, utilization and regulation should be best taken at smaller scales starting from landscape elements upwards, and at small intervals like a season or year and so on.

The Forest Act, the Wildlife Act and the Environment Act etc. provide some legal backing for guarding nature from harm. However, environmental safety lies not in various Acts, but in the mode of implementation. Political interference, social compulsions and corruption have rendered our official machinery ineffective. One way of correcting this would be to make the laws more pro-people and locally sensitive.

The emerging view of feasible conservation strategy suggests much needs to be done at the level of governance and educational policies. Firstly, the proposed amendments to Panchayat Raj Act (Anonymous 1993) should explicity recognize and promote rights of Panchayats over biodiversity and its knowledge resources. People may be thought of as stakeholders and not just beneficiaries of such common property resources. Panchayats must also be authorized to regulate trade in bioresources and charge collection fees or cess. Tax revenue should be supplemented by linking part of annual grants for village development to biodiversity conservation. Panchayat registers should be recognized by a special legislation as accounts of Village property both physical and intellectual. Their role as a tool for participatory planning should also be recognized.

On the educational front, the first hand study of biodiversity should become an integral part of biology, geography, social science curricula. Students and teachers must be rewarded for good documentation of Panchayat registers. They should also be provided with attractive, reliable and user friendly field guides for species identification and field methodology manuals.

The Government should back this initiative by implementing similar and more extensive recommendations made by the Karnataka State Planning Board subgroup of Biodiversity (Anonymous 1996). Similarly Minister of Environment and Forests, Government of India might be persuaded to incorporate such pro-people policy in its programmes to follow up on the Convention on Biological Diversity (CBD) and the Agenda 21, accepted by India along with the rest of the international community.

On- Going Programmes

Dr. P. R. Nayak Committee for amendments to Panchayat Raj Act has suggested that the Panchayats can tax the traders for all biodiversity material being collected from within the limits of Panchayat boundaries.

Karnataka State Planning Board proposed a biodiversity policy. It had all the objectives outlined above. The proposal is gathering dust in the Environment Ministry. State Cabinet has still not issued any ordiannce to recognize people's rights not to record them statewise.

The Central Government is now working on a draft bill on biodiversity prepared by the Committee chaired by Dr. M. S. Swaminathan. It hinges upon a countrywide systematic documentation and information sharing system based on Panchayat Biodiversity Register (PBR). It is said to include plans for preparing such biodiversity registers in all Panchayats.

The Karnataka state Department of Ecology and Environment has recently approved the project proposed by the Centre for Ecological Sciences, Indian Institute of Science. It will start next year and continue for at least four years. It will be implemented by Karnataka State Council for Science and Technology, with the help of Foundation of Revitalization of Local Health Traditions. The proposed project will not stop just at documenting the registers, but it also contemplates giving honours and awards for knowledgeable individuals, those who cultivate traditional varieties, those who contribute to special conservation efforts like for instance the birds of Uluwe or Kokre Bellur. A computerized information system will be established. It is hoped that not just the government agencies but even villegers will be able to see the entire picture.

At the national level, the proposed Biological Diversity Act 1997 would hopefully be passed and there would be a National Biodiversity Authority, State Biodiversity Board at the State level and Biodiversity Management Committees in the local bodies - at blocks/ villages to promote the conservation, chronicling and sustainable use of biodiversity wealth of the area. Biodiversity registers at the village Panchayat level and its computerization at Taluk, District, State and Central level might serve as an efficient information system towards this end.

The political will for tribal empowerment seems to be riding high in various spheres due to social compulsions. Time is ripe for the farmers, artisans, fisherfolk, shepherds and conservationists to exert pressure on their political leaders to frame strategies and enact legislation for ensuring sustainable development and nature conservation.

Few could understand Gandhiji's massive personality and limitless thoughts well. We do not follow much of it. But in this 50th year of India's Independence, even if we move an inch towards this *"gramarajya"* concept, it will be a great tribute to a great visionary of modern India.

Acknowledgement

Prof. Madhav Gadgil of Centre for Ecological Sciences (CES), Indian Institute of Science (IISc.), Bangalore, provided the opportunity for pioneering 'grassroots conservation strategies' investigation under the Biodiversity Conservation Prioritization Project (BCPP). The financial support was given by Karnataka State Council for Science and Technology (KSCST), Bangalore. Sri K. Krishna and Sri P. Ishwara Bhat and a number of students of Sri Bhuvanendra College, Karkala, as well as Sri M. Venkatesh Ranade and Sri Kunjira Moolya of Mala village assisted me in the fieldwork. Sri Utkarsh Ghate, Sri Harish R. Bhat and Dr. P. Pramod of CES, IISc. gave necessary guidance. Prof. S. R. Malli, Principal, Sri Bhuvanendra College, Karkala, gave encouragement and support. I express my deep sense of gratitude to all of them.

References

1. ACHAR K. P., 1996 A report on Monitoring Environmental Status and Dynamics of Mala village, Centre for Environmental Education (Southern Region), Bangalore.
2. ACHAR K. P., 1996 Inventorying, Monitoring and Conserving the Biodiversity of the Western Ghats through local people and Colleges: A case study of Mala village, Western Ghats Biodiversity Network. Indian Institute of Science, Bangalore.
3. ANATOLE F. KRATTIGER et. al., 1994. Widening Perspective on Biodiversity (IUCN Publication)
4. ANONYMOUS 1993. The Karnataka Panchayat Raj Act, Govt. Publications, Bangalore 1993.
5. ANONYMOUS 1995. Managing Sustainable Development Experience from Environmental Management Plan for Dakshina Kannada, India, Danida-DFEE.

6. ANONYMOUS 1996. Report of the Subgroup on Biodiversity, Bangalore. The Karnataka State Planning Board.

7. DAMLE, CHANDRASHEKARA, 1991. Agrarian Relations and Land Reforms in Dakshina Kannada District, Karnataka. In Mangalore University Decennial Volume pp. 145-159.

8. FORMAN, R. T. T. and M. GORDAN 1986 'Landscape Ecology'. John Wiley and Sons, New York.

9. GADGIL, M. and R. GUHA, 1995. 'Ecology and Equity', Penguin, India, pp xi+213.

10. GADGIL, el. al. 1996. 'Recording India's Wealth: People's Biodiversity Register, Amruth, Vol. 1, 5, Oct 1996 pp 1-16.

11. GIRIAPPA S. 1991. 'Cropping pattern changes in Dakshina Kannada and Kodagu'. In Mangalore University, Decennial Volume pp. 172-180.

12. GOKHALEY and R. WALANKAR, RANWA 1996. Documenting people's knowledge about Biodiversity. Technical Report-6.

13. JAYARAM, K.C. 1996. 'A Manual for Field Identification of common Fresh Water Fishes of Karnataka. WWF-India.

14. LAWRENCE D'SOUZA, S. J. 1991. 'Koragas' - A Primitive Tribe of South India.

15. PRATER, S. H. 1993. 'The Book of Indian Animals' BNHS, Bombay, India.

16. RANJIT LAL et al., 1994, 'Directory of National Praks and Sanctuaries in Karnataka: New Delhi, India.

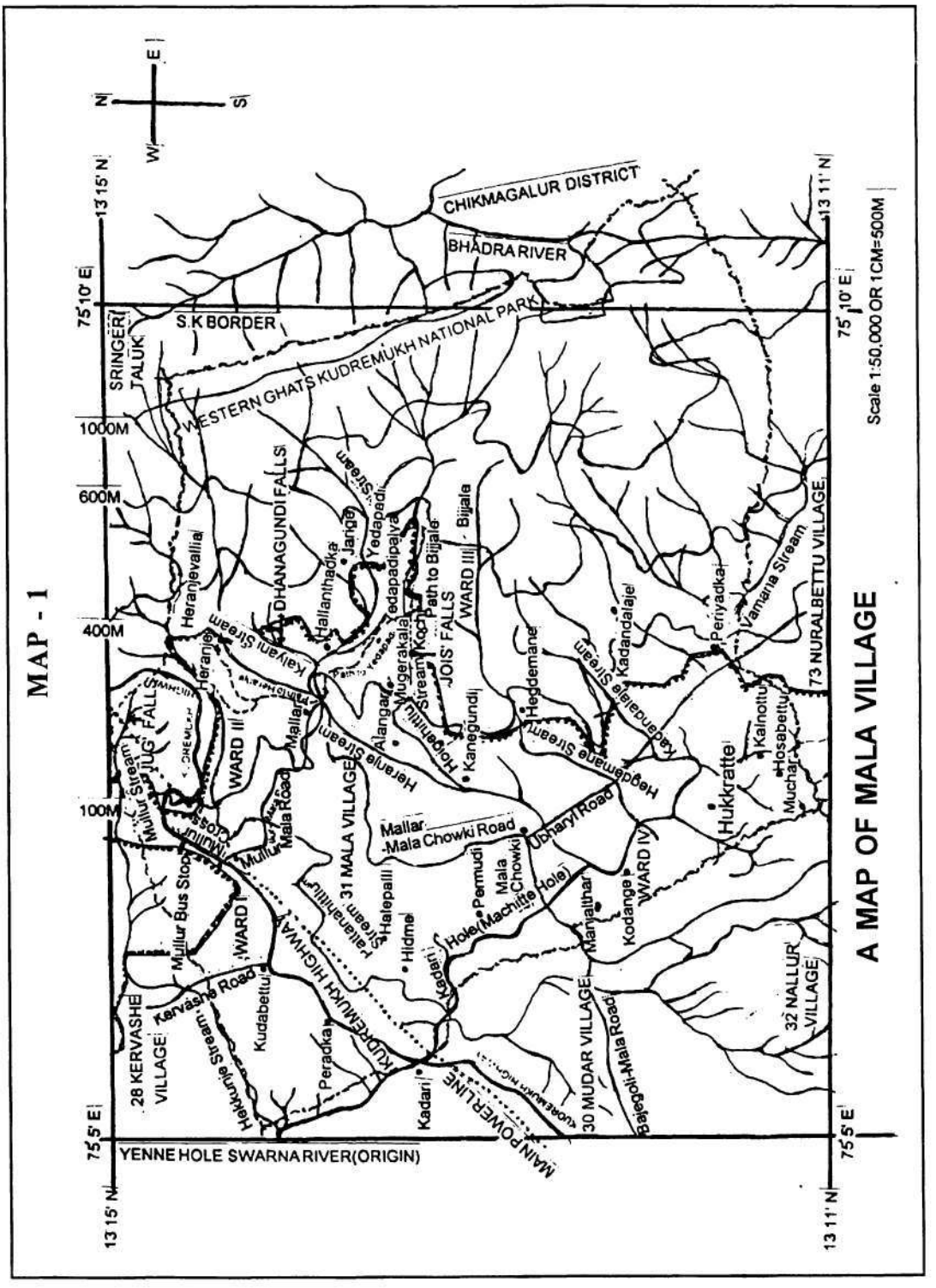
17. SALIM ALI, 1996. The Book of Indian Birds, B.N.H.S. Bombay.

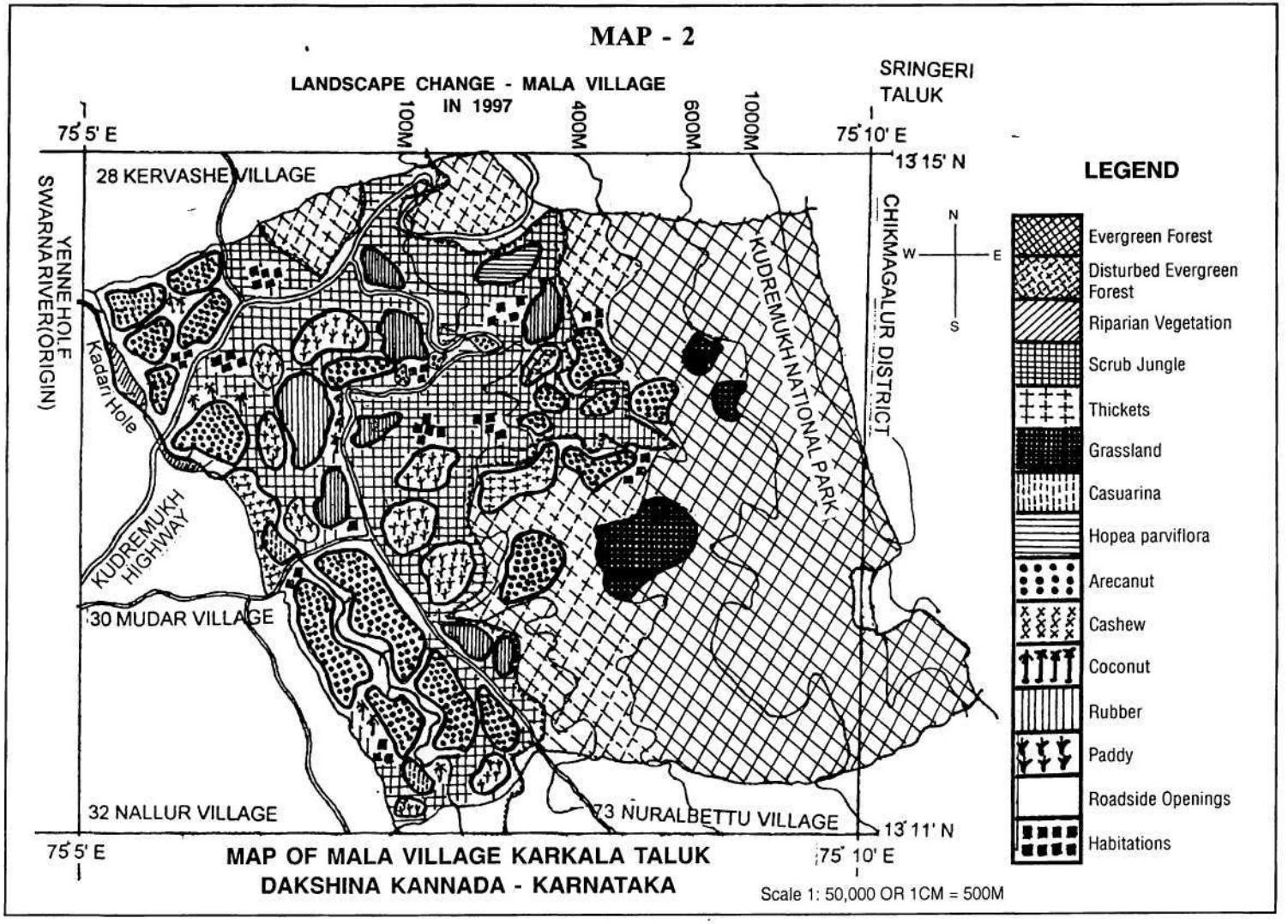
18. SRINIVASA PRABHU, Kadari 1967 & 1996. Pashuraksha Sangraha, Mala.

19. SHESHAGIRI RAO P.R., Winfred Thomas, Yogesh Gokhale, Utkarsh Gokhale, Madhav Gadgil, 1996 Srushitgyaan. A Methodology Manual for documenting Peoples Priorities for Biodiversity Conservation, CES, IISc., Bangalore.

20. UTKARSH GHATE, 1997 a. An Action Plan for Panchayat level Biodiversity conservation (Personal Communication)

21. UTKARSH GHATE, 1997 b. Panchayat Biodiversity Registers: A Programme for People's Empowerment for sustainable use and benefit sharing. (Personal Communication)


MAP - 1
A MAP OF MALA VILLAGE
Scale 1:50,000 OR 1CM=500M
CHIKMAGALUR DISTRICT
BHADRA RIVER
S.K BORDER
SRINGERI TALUK
WESTERN GHATS KUDREMUKH NATIONAL PARK
DHANAGUNDI FALLS
JOIS' FALLS
Path to Bijala
Bijala
Yedapadi
Yedapadipalya
Jangla
Hallanthadka
Heranjevallia
Heranje
Kaiyani Stream
Mugerakala
Alangar
Hoppanhilli
Kanegundi
Heddemane
Kadandalaje
Periyadka
Vamana Stream
73 NURALBETTU VILLAGE
Kadandalaje Stream
Heddemane Stream
Hukkratte
Kainottu
Hosabettu
Muchar
Mallar
Mala Road
Mallar-Mala Chowki Road
Upharyl Road
Mala Chowki
Permudi
Halepalli
Hidme
Kadari
Hole/Machitte Hole
Manjalthar
Kodange
WARD IV
WARD III
WARD II
WARD I
31 MALA VILLAGE
Heranje Stream
Mullur Stream
Mullur Bus Stop
Mullur
Palianahilli Stream
KUDREMUKH HIGHWAY
Kervashe Road
Kudabettu
Peradka
Hekkunje Stream
28 KERVASHE VILLAGE
30 MUDAR VILLAGE
Bajegoli-Mala Road
32 NALLUR VILLAGE
MAIN POWER LINE
KUDREMUKH MONTAGE
YENNE HOLE SWARNA RIVER(ORIGIN)
13 15' N
13 11' N
75 5' E
75 10' E
1000M
600M
400M
100M
N
S
E
W


MAP - 2
LANDSCAPE CHANGE - MALA VILLAGE
IN 1997
SRINGERI
TALUK
100M
400M
600M
1000M
75° 5' E
75° 10' E
13° 15' N
28 KERVASHE VILLAGE
YENNEHOLE
SWARNA RIVER(ORIGIN)
Kadari Hole
KUDREMUKH HIGHWAY
30 MUDAR VILLAGE
KUDREMUKH NATIONAL PARK
CHIKMAGALUR DISTRICT
N
W
E
S
32 NALLUR VILLAGE
73 NURALBETTU VILLAGE
13° 11' N
75° 5' E
75° 10' E
MAP OF MALA VILLAGE KARKALA TALUK
DAKSHINA KANNADA - KARNATAKA
Scale 1: 50,000 OR 1CM = 500M
LEGEND
Evergreen Forest
Disturbed Evergreen Forest
Riparian Vegetation
Scrub Jungle
Thickets
Grassland
Casuarina
Hopea parviflora
Arecanut
Cashew
Coconut
Rubber
Paddy
Roadside Openings
Habitations

MAP - 3

MALA VILLAGE

KARKALA TALUK, DAKSHINA KANNADA DISTRICT

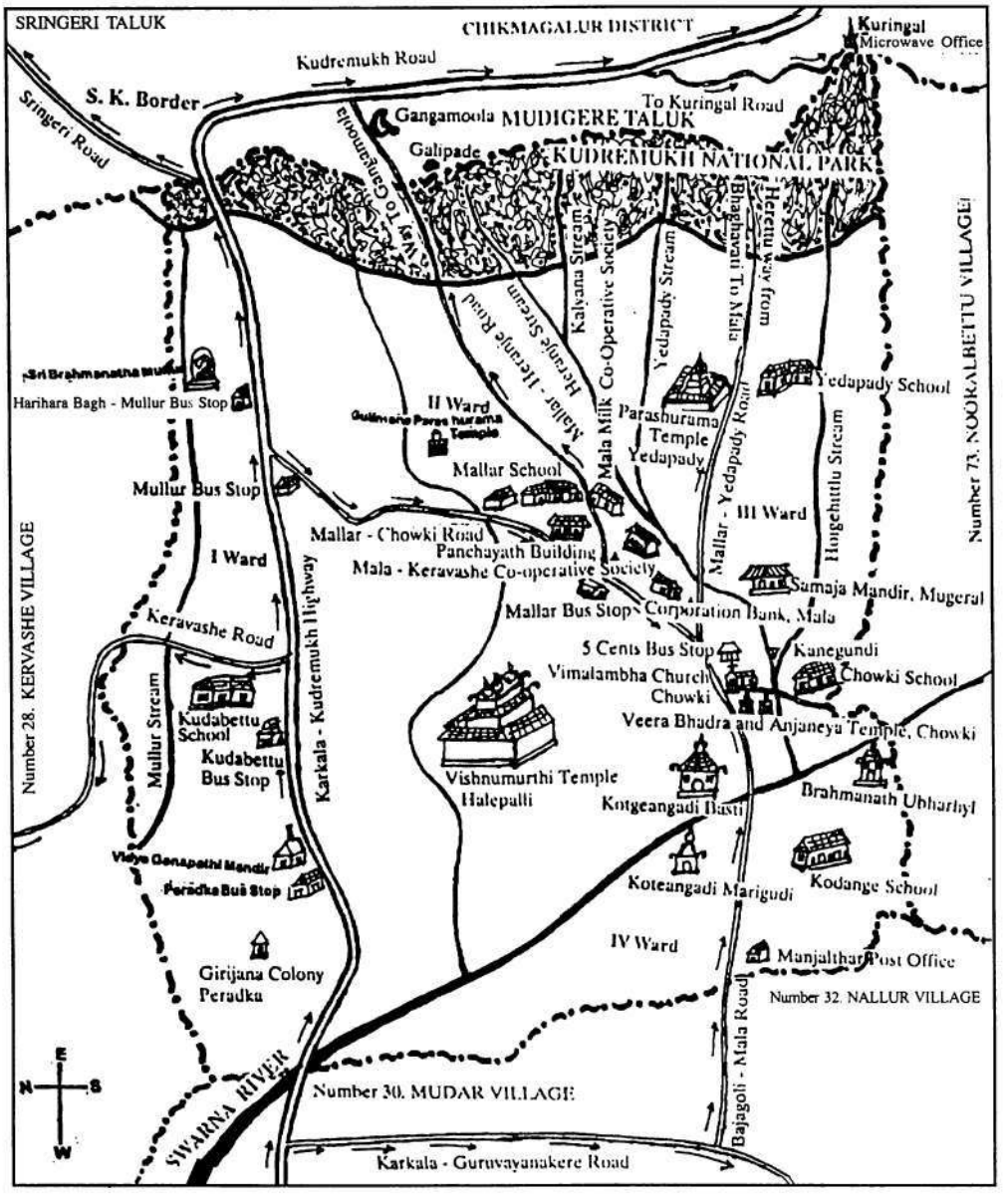


Table-1 : Major User Groups of Mala Village

Sl. No.	User Groups	Communit	Population	Occupation	Biodiversity Adverse Practice
1	NTFP Collectors	8, 9, 10	100	Coolie	Overexploit
2	Fishermen	11	12	Fishing	Dynamite
3	Medicinal Herb Collectors	7, 8, 9	10	Coolie	Overexploit
4	Basket Weavers	8, 10	15	Weaving	Overexploit
5	Mat Weavers	8, 10	7	Weaving	Overexploit
6	Honey and Beeswax collectors	8	12	Coolie	ns
7	Fuel wood collectors	2, 7, 9	60	Coolie	Scrub
8	Toddy Tappers	2	7	Tapping	ns
9	Agriculturists (Paddy Cultivators)	1, 2, 3, 4	200	Agriculture	ns
10	Horticulturists (Arecanut/Coconut growers)	1, 2, 3, 4	170	Horticulture	Excess Manure, Chemicals
11	Rubber Planters	3, 6	25	Planter	ns
12	Rubber Tappers	6	25	Tapping	ns
13	Traders	3, 4, 9	11	Business	Overexploit

COMMUNITIES: 1. Bunts 2. Billavas 3. Chitpavans 4. Jains 5. Vishwakarmas 6. Christians 7. Moolyas 8. Malekudiyas 9. Marati Naikas 10. Korages 11. Mera 12. Nalke 13. Parava

Table-2 : Main Knowledge Individuals of Mala Village

Sl. No	Knowledgable Individuals	Community	Occupation	Biodiversity Adverse Practice
1	Sri Kadari Srinivasa	RSB	Agriculturist	Cattle, herbal, NTFP, medicinal
2	Sri Kunjira Moolya	Moolya	Labourer medicine	Human, herbal
3	Sri M. Govinda Hegde	Hegde	Farmer medicine	Human, herbal
4	Sri Ramanna Poojari	Billava	Farmer medicine	Cattle, herbal
5	Smt. Sundari Ramanna Poojarthi	Billava	Household	Women & Children medicine
6	Smt. Muthu Poojarthi	Billava	Household	Midwife, Children medicine
7	Smt Muddu Merthi	Mera	Household	Midwife, Children medicine
8	Dr. M. Venkatesh Marate	Chitpavan	Doctor	Ecological History
9	Sri Babu Gowda	Malekudiya	Agriculturist	NTFP
10	Sri Anni Gowda	Malekudiya	Agriculturist	Honey
11	Smt. Warija Moolya	Moolya	Housewife	Fuelwood
12	Sri Bugre Gowda	Malekudiya	Artisan	Basket weaving
13	Sri Babu Gowda	Malekudiya	Artisan	Basket weaving
14	Sri Babu Sherigara	Moolya	Artisan	Basket weaving
15	Sri Koraga Shetty	Bunts	Artisan	Basket weaving
16	Smt. Akku	Malekudiya	Artisan	Gorabu
17	Smt. Padma	Malekudiya	Artisan	Mat weaving

Table-3 : Distribution of LSE* Types Around Mala

Sl. No.	Lse Type	Local Name	Landuse Pattern	No. of Settlements Involved	Ownership
1	Evergreen Forest	Kadu	Forest	Bijjale, Jarige, Yedapady, Heranje	Forest Department (FD
2	Riparian Forest	Holebadi Kadu	Forest	Banks of Kadari Hole & Stream	FD and Private
3	Scrub Jungle	Kuruchalu	Forest	Sunkadakatte Kangegundi	FD
4	Thickets	Podekadu	Forest	Yedapady manjalthar	FD
5	Grasslands	Hullinagudda	Grazing Field	Bijjale, Heranje Kadandalaje	FD
6	Casuarina	Galimara Padi	Social Forest	Manjalthar Hukratte	FD
7	Hopea parviflora	Bogida Padi	Social Forest	Kattemane (Mallar) Kasin bail	Private
8	Arecanut	Adike Thota	Plantation	Yedapady, Heranje Kasin bail	Private
9	Coconut	Tengina Thota	Plantation	Yedapady, Heranje Mallar, Kodange, Mata	Private
10	Cashewnut	Beejada Padi	Plantation	Yedapady, Heranje Chowki Hukratte	Private
11	Rubber	Rubber Thota	Plantation	Heranje, Mallar Badakodi, Chowki	Private
12	Paddy	Gadde	Cultivation	Bermalli, Kesinbail, Kodange, Mata	Private
13	Roadside openings	Raste Badi	Mosaic	Mullar to Chowki Manjalthar to Hukratte	Government
14	Habitations	Vasasthana	Mosaic	All settlements, scattered houses	Private & Government

* Landscape Element

Table-4 : PLANTS ACCORDED HIGH CONSERVATION PRIORITY

Sl. No.	PRIORITY PLANTS	LOCAL NAME	LSE TYPE	STATUS	VALUE ASCRIBED BY DIFFERENT USER GROUPS														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	*Garcinia indica*	Bhirundi	Evergreen	Common	b	b	b								a				b
2	*Myristica malabarica*	Ramapatre	Evergreen	Common	b	b	b							a	a				b
3	*Cinnamomum verum*	Dalchini	Evergreen	Common	b	b	b							a	a				b
4	*Artocarpus lakoocha*	Vatehuli	Evergreen	Common	b	b	b								a				b
5	*Artocarpus heterophyllus*	Halasu	Evergreen	Common	b	b	b								a				b
6	*Artocarpus hirsutus*	Hebbalasu	Habitation	Common	b	b	b								a			a	b
7	*Hopea parviflora*	Bogi	Habitation	Common	b	b	b	a										a	b
8	*Hopea ponga*	Karmar	Hopea Plantation	Common	b	b	b	a										a	b
9	*Terminalia crenulata*	Matti	Evergreen	Common	b	b	b	a										a	b
10	*Terminalia paniculata*	Marva	Evergreen	Common	b	b	b	a										a	b
11	*Lagerstroemia lanceolata*	Nandi	Evergreen	Common	b	b	b	a										a	b
12	*Tectona grandis*	Tega	Habitations	Common	b	b	b											a	b
13	*Syzygium aromaticum*	Lavanga	Evergreen	Rare	b	b	b							a	a			a	b
14	*Ailanthus malabarica*	Gugul	Habitations	Rare	b	b	b								a			a	b
15	*Madhuca longifolia*	Nanil	Riparian	Common											a	a			b

USER GROUPS: 1. Agriculturists 2. Horticulturists 3. Honey & Beewax Collectors 4. Fuelwood collectors 5. Rubber Planters 6. Rubber Tappers 7. Toddy Tappers 8. Potters 9. Fisherman 10. Medicinal Herb Collectors 11. NTFP Collectors 12. Basket Weavers 13. Mat Weavers 14. Artisana 15 Traders

VALUES: a. Subsistance b. Commercial c. Religious d. Cultural e. Nuisance f. Environmental

Table-4 : Continued...

Sl. No.	PRIORITY PLANTS	LOCAL NAME	LSE TYPE	STATUS	VALUE ASCRIBED BY DIFFERENT USER GROUPS														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	*Calamus* sp	Betta	Evergreen	Rare	b	b	b	b							a	a			b
17	*Bambusa* sp	Bidiru	Evergreen	Rare	b	b	b	b							a	a		a	b
18	*Ochlandra* sp	Vate	Evergreen	Rare	b	b		b							a	a		a	b
19	*Caryota urens*	Byne	Habitations	Rare	b	b					a								
20	*Areca catechu*	Adike	Areeu Plantation	Common	b	b	b	b											b
21	*Cocos nucifera*	Tengu	Habitations	Common	b	b		b			a								b
22	*Embelica officinalis*	Nelli	Evergreen	Common	b	b								a	a				b
23	*Strychnos nuxvomica*	Kaver	Evergreen	Common	e	e								a					
24	*Pandanus furcatus*	Mundevu	Riparian	Common	e	e											a		
25	*Calophyllum apetalum*	Honne	Evergreen	Common	b	b	b	a											b
26	*Poeciloneuron indicum*	Baligai	Evergreen	Common	b	b	b	a											b
27	*Rouwolfia serpentina*	Sarpaganda	Evergreen	Rare										a	a				b
28	*Ficus religiosa*	Ashwatha	Roadside	Common	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c
29	*Myristica fragrans*	Jaikai	Evergreen	Rare	b	b	b	b						a	a				b
30	*Hevea brasilensis*	Rubber	Rubber Plantation	Common	e	e	e	e	a	a	e	e	e	e	e	e	e	e	e

Table-5 : Major NTFP Collections From Mala Village

Sl. No.	Name of the Species	Local Name	Parts Used	Uses
1	*Garcinia combogia*	Manthpuli	Fruits	Pickles
2	*Garcinia indica*	Bheerundi	Fruits	Edible
3	*Artocarpus lakoacha*	Vatehuli	Fruits	Pickles
4	*Tamarindus indicus*	Hunase huli	Fruits	Condiments
5	*Myristica malabarica*	Rampatre	Fruits	Condiments
6	*Syzigium caryophyllatum*	Lavanga	Flower bud	Condiments
7	*Cunnamomum verum*	Dalachiru	Bark, leaves	Condiments
8	*Ailanthus malabaricus*	Maddidupa, Gug	Resin	Perfumes
9	*Vateria indica*	Dhupa	Seeds	Varnish
10	*Sapindus lauriolius*	Norekai	Fruits	Detergent
11	*Emblica officinalis*	Nellikai	Fruits	Pickle
12	*Elettaria cardamomum*	Yelakki	Fruits	Condiments
13	*Piper nigrum*	Karimenasu	Fruits	Condiments
14	*Mangifera indica*	Mavu	Fruits	Edible
15	*Anacardium occidentale*	Godambi	Seed	Edible
16	*Spondias mangifera*	Amte	Fruits	Pickle
17	*Acacia concinna*	Sheegekai	Fruits	Detergent
18	*Acacia catechu*	Kachu	Bark	Tanning
19	*Terminalia chebula*	Alale	Fruits	Tanning
20	*Pandanus sp.*	Mundaga	Leaves	Mat making
21	*Calamus sp.*	Bettha	Stem	Basket making
22	*Ochalandra sp.*	Vate	Stem	Basket making

Table-6 : Priority Animals of Mala Village

Sl. No.	Species	Local Name	Lse Type	Status	Values
	A. MAMMALS				
1	Lion Tailed Monkey	Singalika	Forest	Rare	
2	Slender Loris	Kadupapa	Forest	Rare	
3	Leopard (Panther)	Chirate	Forest	Rare	Nuisa
4	Gaur/Indian Bison	Katee	Forest & Grassland	Rare	Nuisa
5	Sambar	Kadave	Forest & Grassland	Rare	
6	Chital/Spotted Deer	Jinke	Forest & Grassland	Rare	
7	Indian Chevrotian	Barka	Forest	Rare	
8	Gaint Squirrel	Daithya Alilu	Forest	Rare	
9	Mongoose	Mungusi	Forest	Rare	
10	Wild Boar*	Kadu Handi	Forest	Common	Nuisa
	B. BIRDS				
11	Common Grey Hornbill	Kodukokku	Evergreen	Rare	
12	Malabar Grey Hornbill	Kodukokku	Evergreen	Rare	
13	Barn owl	Gube	Habitation	Rare	
14	Bee-eater	Jennonabaku	Paddy fields	Common	
15	Peafowl	Navilu	Habitations	Common	
16	Grey jungle fowl	Kadukoli	Serub	Rare	
C.	**FISHES**				
17	*Channa* sp.	Madengi	Riparian	Common	
18	*Ophiocephalus* sp.	Pilikucchi Madenji	Riparian	Common	
19	*Labeo* sp.	Kuruvai	Riparian	Common	
20	*Wallago* sp.	Bale	Riparian	Rare	
21	*Belone* sp.	Konti	Riparian	Rare	
22	Fresh water Eel	Puriyolu	Riparian	Rare	

USE GROUPS: 1. Agriculturists 2. Horticulturists 3. Honey & Beeswax Collectors 4. Fuelwood 6. Rubber Tappers 7. Toddy Tappers 8. Potters 9. Fishermen 10. Medicinal herb collectors 11. NTFP Collectors 12. Basket weavers 13. Mat weavers 14. Artisans 15. Traders.

*- Needs regulation, rest all conservation.

EXPERIENCES IN CONSERVATION AND PROMOTION MEDICINAL PLANTS IN SOUTHERN INDIA

M. Abdul Kareem
Foundation for Revitalisation of Local Health Traditions
50, MSH Layout, IInd stage, IIIrd Main, Anandnagar, Bangalore 24.

Abstract

Much of the rural population in developing countries depends on medicinal plants for their primary health care needs. India is one of the richest country in ethno-medicinal traditions and Biodiversity. Today there are over 4 lakh licensed and registered medical practitioners of codified systems of Indian system of medicines and millions of folk practitioners in India. The research studies reveal that around 7,500 medicinal species are used by different ethnic communities in India for their various healthcare practices. Around 5,000 traditional medicine manufacturing units in the country have an annual turnover of over Rs. 1,000 cores/ years. Today there is a growing interest in medicinal plants by pharmaceutical and cosmetic companies. This has resulted in a surging demand for herbal products of many wild medicinal plant population. The unregulated harvesting & habitat degradation threatens the wild medicinal flora of India. Diversion of forest land for agricultural development, timber plantations and other urban associated developments has also incurred pressure on wild medicinal flora of India. Diversion of forest land for agricultural development, timber plantations and other urban associated developments has also incurred pressure on wild medicinal plant population. This situation is further aggravated for many of these species. Their habitat specificity, reproductive biology etc. is not adequately known. We have very little information on all these in relation to socio-economic issues also. Hence there is an urgent need for conservation action. On this background Foundation for Revitalization of Local Health Tradition(FRLHT), a non-governmental organization based in Bangalore is attempting to establish a system to conserve and sustainably use of medicinal plants, focusing on primary health care. It has established a network of a) *in situ* reserves across all the vegetation types of southern India b) ethno-botanical parks to create living collections of all the medicinal plants known

to various ethnic communities of south India and c) Joint Forest Management projects to propagate medicinal plants in degraded forest areas and harvest them sustainably. An attempt is being made to establish a chain of medicinal plant nurseries to multiply and supply as per the need of various user groups. A focused research program on inventory, prioritization, ecology, mapping, agrotechnology is carried out to guide conservation action. Various communication materials like films, illustrated books, posters are published to create public awareness.

Introduction

Around 80% of the world's population depends on traditional medicine for their primary health care which are plant based. Medicinal plants have become so important that they represent an inexhaustible reservoir for purpose of isolation of active chemical compounds for treatment of major diseases like Aids, Cancer etc. Conservative estimates put the economic value of medicinal plant related trade in India to be of the order of Rs. 1000 crores/year and world trade to be over US $ 60 billion. Unfortunately very little information on this is available.

The general belief that medicinal plants will always be available in plenty as raw materials is, unfortunately, not true. The vegetation of the world is being fast depleted at an alarming rate. The tropical moist forests, which is the home for about half of the world's plant species, are particularly in danger, as these forests are declining at an estimated 16.8 million ha./ annum (UNEP/FAO). From the estimated 270,000 kinds of higher vascular plants on the planet today, over 10% are threatened with extinction. Around 14-28% of these plants are reported to be used for medicinal purposes.

In India from the estimated 45,000 species of plants, 17,000 species are the flowering plants. Of these, about 40-45% are endemic to the region. These are largely concentrated in the three major biogeographical zones, viz. the western and eastern Himalayas and the Western Ghats, which are also recognized amongst 18 global Biodiversity Hot Spots. It is estimated that around 10% of the flora is threatened with extinction. More than 7,500 species are used for human & veterinary health care by 4,635 ethnic communities of India. Over 95% of the medicinal plants used by the Indian industry today are collected from the wild. Less than 20 species of plants are under commercial cultivation, while over 400 species are used in production by industry. Over 70% of the plant collections involve destructive harvesting because of the use in large quantities of parts like roots, bark, wood, stem and whole plant. Increasing human population and growing demand for land for socio-economic

development lead to increasing rates of destruction and degradation of natural habitats including forests and woodlands, putting many medicinal plants under risk of genetic erosion and even extinction. Hence there is an urgent need for conservation of these species before these valuable genetic resources are lost.

These species can be conserved by a combination of measure *in situ* by maintaining plant communities in their natural habitat as nature reserves and thus allowing continuos evolution within natural environments and *ex situ* (by developing facilities for artificial long and medium term conservation by establishment of genetic enhancement centers, gene banks through seeds & tissue culture, pollen storage and *in-vivo* and *in vitro* preservation.

FRLHT is trying to take a holistic approach in establishing a system to conserve and sustainably use medicinal plants, particularly in the area of primary health care and to revive the popular local health traditions. It is currently coordinating a project in three states -Kerala, Tamilnadu & Karnataka in south India.

Network Of Medicinal Plants

Networks of thirty *in situ* - Medicinal Plant Conservation Areas (MPCAs), fifteen *ex situ* - Medicinal Plants Conservation Parks (MPCPs) and ten Medicinal Plants Development Area (MPDAs) have been established in these three states.

1. Medicinal Plants Conservation Areas (MPCAs):

A chain of 30 Medicinal Plant Conservation Areas have been established in collaboration with the State Forest Departments of Tamilnadu, Kerala and Karnataka. There are 12 in Karnataka, 7 in Kerala & 11 in Tamilnadu. Nine of these MPCAs are within the existing Protected Area Network & 21 of them are located in reserve forests. The altitudinal and spatial distribution of the MPCAs well covers centers of endemism and species richness, traditionally acknowledged centers of medicinal plant wealth, and distinct biogeographic zones of southern peninsular India.

Each MPCA has been demarcated and covers an area of about 200 ha. It covers almost all the major forest types. Twenty of them are scattered along the Western Ghats, the southern part of which has been recognized as a conservation 'hot spot' by the International Union for Conservation of Nature and Natural Resources (IUCN). Initial floristic surveys reveal that nearly 60% of the known medicinal plant species of southern India have been catalogued and herbarium specimens prepared. Vegetation and ecological data recorded along belt transects at about 1.5% sampling intensity in each MPCA are currently being computerized for analysis.

2. Medicinal Plants Conservation Parks (MPCPs)

Fifteen parks have been set up in distinct agro-ecological zones. These MPCPs have areas varying between 6 and 10 ha and are owned and managed by community-based NGO's with experience in environment/health related work. Each MPCP has three major components:

a) An *Ethno-Medicinal Forest Park* wherein medicinal flora known to local ethnic communities are being grown in polyculture models. Accessions from different wild locations would be introduced to add an element of genetic variation.

b) An *Outreach Nursery* that grows medicinal plants for the public, propagating suitable species for home herbal gardens as well as species categorized as rare, endangered, or otherwise threatened (RET) in southern India.

c) *Herbarium, Seed and Raw Drug Center* that displays herbarium specimen, samples of seeds and raw drugs of medicinal plants of the region or district for purposes of training, study and education. Centered around these MPCPs, the NGOs implement various people-oriented programs to conserve and revitalize medicinal plants of local health traditions.

3. Medicinal Plants Development Areas (MPDAs)

They are located on degraded forest lands on which adjacent village communities partly depend for their livelihood. MPDAs are designed to test different models of Joint Forest Management between the Forest Department and local communities. Here, the MPDAs are intensively planted with various medicinal plants which have a demand in the local market. Profits through harvesting and sale of products are shared between the FD and the local community on mutually agreed terms. MPDAs seek to increase the economic stake of local communities in rehabilitation and conservation of degraded forest lands.

Involvment Of Local Communities:

The entire network of the 55 medicinal plants conservation sites also has a vigorous community participation program to seek involvement of local communities in their longterm conservation. By using existing village-level organizations, such as women's groups and farmer clubs, wider appreciation of the role and importance of medicinal plants in the rural economy and health care is being sought. On the cultural level, an extensive effort to document and use indigenous knowledge is being attempted.

In villages where the MPCPs are operating, initial public response to developing home herbal gardens and attending related medicinal plant use training have been encouraging. In some MPCPs in the first six months of launching the program, 300 to 400 women started

home herbal gardens. The demand for suitable planting materials and training on their medicinal uses is steadily increasing.

Threat Status Assessment:

For a focused conservation effort to save the medicinal species in southern India a process of prioritization of native medicinal species and elimination from the checklist, exotic & species which have not naturalized in this region, had to be undertaken. The process of prioritization involved compilation and analysis of : a) Data on consumption of plants (including part used) by the traditional pharmaceutical industries; b) Listing in the Red Data Book of Indian Plants (BSI) and c) Listing of endemic plants of the region known to be in medicinal use. This resulted in a list of around 308 species. In order to further narrow down attention towards species which are perceived to be threatened, a systematic threat status assessment has been undertaken for selected species from this prioritized list. The assignment of threat status to each selected taxon, is based upon the latest IUCN Red list categories, and done through a unique threat categorization process called the Conservation Assessment Management Plan (CAMP).

The CAMP workshop process is intensive, interactive and unique in its ability to facilitate objective and systematic prioritization of research and management actions needed for species conservation both *insitu* and *exsitu*. Several experts (field botanists, forest managers, scientists, taxonomists etc.) from the three states are invited to discuss in the CAMP workshop for each taxon in 1. Assigning new IUCN Red list Category of threat to each species. 2. Making recommendation for research and management activities to contribute to the taxon conservation. 3. Making recommendation for captive programs that can contribute to the conservation of the taxon.

Out of 112 medicinal plant species taken for assessment the threat status got assigned to the following categories Extinct - 3, Extinct in wild - 1, Critically Endangered - 18, Endangered - 27, Vulnerable - 49, and Low Risk - 14. (Refer list) For these species a detailed/focused population assessment exercise is being conducted and urgent protective actions are being initiated in the MPCA sites.

Eco-Distribution Mapping:

We have mapped the ecodistribution of 90 to 100 pritorized species using GIS systems. These maps spell out the distinct pattern of species in the natural occurrence, its altitude, rainfall, potential areas of occurrence and the actual area of occurrence. This information is consolidated from the literature, herbarium and MPCA surveys. These maps are decisive in identifying important conservation areas for the targeted species.

THE RED LIST OF MEDICINAL PLANT SPECIES IN SOUTHERN INDIA
(ASSESSED THROUGH THE THREE C.A.M.P WORKSHOPS ORGANISED SO FAR)

1.	*Acorus calamus* L.	VU/R
2.	*Adenia hondala* (Gaertner) Wilde	VU/R
3.	*Adhatoda beddomei* C.B. Clarke	CR/G
4.	*Aegle marmelos* Corr.	VU/R
5.	*Aerva wightii* hook.f.	EX
6.	*Amorphophallus commutatus* Engl.	VU/G
7.	*Amorphophallus paoenifolius* (Burm. f.) Wallich ex Nees	VU/R
8.	*Ampelocissus arnottiana* Planch.	EN/R
9.	*Ampelocissus araneosa* Planch.	VU/G
10.	*Aphanamixis polystachya* (Wall.) Parker	VU/R
11.	*Aristolochia tagala* Cham.	VU/R
12.	*Artocarpus hirsutus* lam.	VU/G
13.	*Asparagus rottleri* Bak.	EX
14.	*Baliospermum montanum* (Willd.) Muell-Arg.	VU/R
15.	*Calophyllum apetalum* Willd.	VU/R
16.	*Canarium strictum* Roxb.	VU/G
17	*Cayratia pedata* (Lam.) Juss. ex Gagnepain var glabra Gam	CR/G
18.	*Celastrus paniculata* Willd.	VU/R
19.	*Chonemorpha fragrans* (Moom) Alston	EN/R
20.	*Cinnamomum wightii* Meissan	VU/R
21.	*Cinnamomum sulphuratum* Nees	VU/G
22.	*Cinnamomum macrocarpum* Hook. f.	VU/G
23.	Commiphora mukul Engl.	VU/R
24.	Coscinium fenestratum (Gaertn) Coleb.	CR/G
25.	*Curcuma pseudomontana* Graham	VU/G
26.	*Cycas circinalis* L.	CR/R
27	*Cyclea fissicalyx* Dunn D	EN/G
28.	*Decalepis hamiltonii* Wt. & Arn.	EN/G
29.	*Diospyros candolleana* Wt.	VU/G
30.	*Diospyros paniculata* Dalz.	VU/G
31.	*Dipterocarpus indicus* Beddome	EN/G
32.	*Drosera peltata* J.E.Sm. Willd.	VU/R
33.	*Drosera indica* L.	LR-NT/R

VU- Vulnerable; R-Rare; CR-Critically Endangered; EX-Extinct; EN-Endangered; LR-Low Risk; EW-Extinct in wild; G-Globally; R-Regionally; NT-Near threatened

34. *Dysoxylum malabaricum* Beddome	EN/G
35. *Embelia ribes Burm.* F.	LR-NT/G
36. *Embelia tsjeriam-cottam* (R. & S.) DC.	VU/R
37. *Eulophia ramentacea* Wt.	CR/G
38. *Eulophia cullenii* (Wt.) Blume	CR/G
39 *Garcinia morella* (Gaertn.) Desr	VU/R
40. *Garcinia travancorica* Beddome	CR/G
41. *Garcinia gummigutta* (L.) Robson	VU/G
42. *Garcinia indica* (L.) Marton	VU/G
43. *Gardenia gummifera* L.	LR-NT/G
44. *Gloriosa superba* L.	LR-NT/R
45. *Glycosmis macrocarpa* Wight	LR-NT/G
46. *Gymnema montanum* (Roxb.) Hook.	EN/G
47 *Gymnema khandalense* Santapau	EN/G
48. *Hedychium coronarium* Koening	LR-NT/R
49 *Heliotropium keralense* Siv & Mani.	EN/G
50. *Helminthostachys zeylanicus* (L.) Hook.	EN/R
51. *Heracleum candolleanum* (Wt. & Arn.) Gamble	VU/G
52. *Holostemma annulare* (Roxb.) K.	VU/G
53. *Humboltia vahliana* Wt.	VU/G
54. *Hydnocarpus macrocarpa* Wight.	VU/G
55. *Hydnocarpus pentandra* (Buch. Ham.) Oken	VU/G
56. *Hydnocarpus alpina* Wt.	EN/R
57 *Janakia arayalpathra* Joseph & Chandrasekaran	CR/G
58. *Kaempferia galanga* L.	CR/R
59. *Kingiodendron pinnatum* (DC.) Harms	EN/G
60. *Knema attenuata* (Hook. & Thoms.) Warb.	LR-NT/G
61. *Lamprachaenium microcephallum* Benth.	EN/G
62. *Madhuca diplostemon* (Clarke) Royen	EN/G
63. *Madhuca longifolia* (Koen.) Macbr.	EN/R
64. *Madhuca insignis* (Radik) Lam.	EX
65. *Madhuca neriifolia* (Moon) H. J. Lam.	VU/R
66. *Mappia foetida* Miers.	VU/R
67. *Michelia nilagirica* Zenk	VU/R & DD/G
68. *Michelia champaca* L.	VU/R
69. *Moringa concanensis* Nimmo ex Dalz. & Gibson	VU/R
70. *Myristica malabarica* Lam.	VU/G
71. *Myristica dactyloides* Gaertn.	VU/R
72. *Nervilia aragoana* Gaud.	EN/R

73.	*Nilgirianthus ciliatus* (Nees) Bremek.	EN/G
74.	*Ochreinauclea missionis* (Wall ex G.Don) Ridsdale	VU/G
75.	*Operculina turpethum* (L.) Silva Manso	LR-NT/R
76.	*Oroxylum indicum* (L.) Benth Ex Kurz	VU/R
77.	*Paphiopedilium druryi* Pfitz.	CR/G
78.	*Persea macrantha* (Nees) Kosterm.	EN/R
79.	*Piper longum* L.	LR-NT/R
80.	*Piper mullesua* Buch. Ham. ex Don G	VU/R
81.	*Piper barberi* Gamble	CR/G
82.	*Piper nigrum* L.	VU/G
83.	*Plectranthus vettiveroides* (Jacob) Singh & Sharma	EW
84.	*Plectranthus nilghericus* Benth.	VU/G
85.	*Pseudarthria viscida* (L.) Wt. & Arn.	LR-NT/R
86.	*Pterocarpus santalinus* L. f.	EN/G
87.	*Pueraria tuberosa* (Roxb. ex Willd.) DC	LR-NT/R
88.	*Raphidophora pertusa* (Roxb.) Schott.	VU/R
89.	*Rauvolfia serpentina* Benth.	EN/R
90.	*Salacia oblonga* Wall. ex Wt. & Arn.	EN/R
91.	*Salacia reticulata* Wt.	EN/R
92.	*Santalum album* L. EN/R &	DD/G
93.	*Saraca asoca* (Roab.) Willd.	EN/R
94.	*Schebera swietenioides* Roxb. Pl.	VU/R
95.	*Semecarpus travancoricus* Beddome	EN/G
96.	*Shorea tumbuggaia* Roxb.	CR/G
97	*Smilax zeylanica* Linn.	VU/R
98.	*Strychnos aenea* A. W. Hill	EN/G
99	*Swertia lawii* (Clarke) Barkill	EN/G
100.	*Swertia corymbosa* (Griseb.) Wt. ex Clarke	VU/G
101.	*Symplocos cochinchinenesis* (Lour.) Moore	LR-NT/R
102.	*Symplocos racemosa* Roxb.	VU/R
103.	*Syzygium travancoricum* Gamble	CR/G
104.	*Terminalia arjuna* (Roxb. ex DC) Wt. & Arn.	LR-NT/R
105.	*Tinospora sinensis* (Lour.) Merr.	VU/R
106.	*Tragia bicolor* Miq.	VU/G
107.	*Trichopus-zeylanicus* Gaertn. var. travancoricus	CR/G
108.	*Trichosanthes anaimalaiensis* Beddome	CR/G
109.	*Utleria salicifolia* Beddome	CR/G
110.	*Valeriana leshchenaultii* DC.	CR/G
111.	*Vateria macrocarpa* B.L. Gupta	CR/G
112.	*Vateria indica* L.	LR-NT/G

Nursery Techniques:

For some of the pritprized species, the study of nursery and seed storage technique is ongoing. There is a developing agrotechnology database from all the published database.

Inventorization Of Medicinal Plants:

An Inventory of medicinal plants is the base for laying any conservation measures. As we are aware that the plant can be tagged as medicinal only if it is referred in any classical text or used by any practitioners of Ayurveda, Siddha, Unani, Tibetan, Homeopathy & Allopathy or used by any individuals as medicine. In this context one of our research projects is inventorizing the medicinal plants used in Ayurveda, Siddha, Unani, Tibetan, Homeopathy & Allopathy or used by any individuals as medicine. In this context one of our research projects is inventorizing the medicinal plants used and mentioned in Ayurveda has already been published. It provides correlation of Sanskrit names with botanical nomenclature, with explicit referencing. In the similar way, work for other aforesaid systems is in progress.

Popularization:

To obtain a broadbased support for the conservation of medicinal plants, their knowledge and traditions, we are popularizing these concepts through publishing books in local languages of S. India, films, puppet shows, posters, conducting Natti vaidya meetings, and other programs which involves more interaction with the local communities.

AN OVERVIEW OF SOME ASPECTS OF THE BIODIVERSITY OF THE KUDREMUKH NATIONAL PARK, KARNATAKA

Hussain, S.A[1] ., Krishnamurthy, S.V[2] .,
Rao, N.R[3] ., and Nagraj.S.[4]

INTRODUCTION

The Western Ghats (WG) of Karnataka are perhaps the most productive and least overexploited region with large tracts of pristine forests, well wooded areas and unspoilt coastline in the peninsula. The region straddles the districts of Uttara Kannada, Dakshina Kannada, Shimoga, Chikmagalur, Hassan and Kodagu and perhaps has the largest combination of plantations, agri-floriculture, fishery and other economic produces. The tracts of dense montane, slope, lowland forests; secondary scrub and woodlands as well as the mangroves of the coastline are endowed with a rich biodiversity of plants, insects, invertebrates, fishes and animals, most of which are economically important.

Physiography

The Western Ghats of peninsular India are a 1600 km long hill chain ranging from 8°N to 16°N latitude. The range has an average width of 100 km and its peaks average about 1500m in the northern portion and about 2600m in the southern part. They form a substantial tract of tropical humid vegetation separated by over 1800 km from the larger contiguous tracts of humid forests of NE Indian hills and SE Asia.

CLIMATE

The general climate is hot and humid with heavy rainfall during the south-west monsoon

1 Biodiversity Initiative Trust., Mangalore, Karnataka.

2 Reader in Environmental Sciences, Kuvempu University, BRP, Shimoga, Karnataka

3 Professor of Botany, JCBM College, Sringeri, Chikmagalur Dist. Karnataka.

4 Lecturer, Dept. of Zoology, JCBM College. Sringeri, Chikmagalur Distt. Karnataka.

months (June-September), which is heralded by massive cloud formations and heavy thunder showers accompanied by gale force winds. Rainfall ranges from 1778 mm to 6350 mm (highest recorded was 12,918 mm in 1946). The average seasonal rainfall is about 3000 mm. Winter months are cooler with mists at nights. The temperatures range between 28°C (maximum) and 17°C (minimum).

FLORA

The area has an estimated 300,000 ha (37%) under forest cover and is characterised by a rich diversity of flora and fauna. Five major types of forests exist in the region. There are 11 wildlife sanctuaries and three National Parks , straddling all the districts of the region. Over 400 species of medicinal, about 180 species of edible plants and several species of indigenous orchids have been found so far in the Western Ghats.

FAUNA

Peninsular India is considered to be true home of the Indian fauna and the western ghats in particular are renowned for their faunistic richness and endemism. Many species, however are now vulnerable or much endangered.

Amphibians : Over 117 species belonging to 21 genera of amphibians are recorded in the forests and coastal areas of this region, of which about 76% are endemic to the region (Daniels, 1992; Sheshachar *et al* 1992; Krisnamurthy & Katre, 1993).

Invertebrates: A large variety of insects including some of the spectacular butterflies and moths occur in the dense evergreen highland and lowland forests. It is estimated that India has over 1400 species of butterfly species of which WG harbours nearly 320 species including 37 endemics and 23 others shared with Sri Lanka (Gaokar *et al* 1996). The area is host to a large variety of freshwater mollusca, some of which are specific to the region.

Fish: The fish fauna of both fresh-water in montane and lowland river streams and water bodies as well as coastal lagoons and backwaters are very many and varied in this region. There is a large commercial coastal fishery of finfish & shell fish in this region.

Reptiles: Dense forests of the region are the home of the King Cobra and Rock Python apart from other smaller reptiles. Many species of tortoises, including the endemic cane turtle, and terrapin are also found in the Western Ghats. The marsh crocodile or mugger was once widely distributed in swamps and larger water bodies of the forested areas. (see list)

Birds : Over 400 species of birds are recorded from the region of which a great number are exclusive to the dense evergreen forests of the Western Ghats.

Mammals : The forests of the area have large herbivores such as Gaur, Spotted deer, Sambar, Barking deer etc. Among the primates the Slender loris and the Lion tailed macaque - one of the most endangered primates are found in evergreen forests of Western Ghats. Of the two species of Pangolin in India, the Indian Pangolin is restricted to peninsular India. Carnivores are represented by Tiger, Leopard, Jungle Cat, Leopard Cat and Fishing Cat, Malabar Civet, Brown Palm Civet, Small Indian Civet, Palm Civet and two species of Mongoose and the wild dog.

Socio-economics

The scenic splendour at this area with its thick forests and lofty mountains, its swift - flowing rivers and peaceful valleys, has been the theme of song and verse for centuries in the spheres of education and culture too, the area has been in the forefront. Comparatively speaking, it had a measure of isolation in the past owing to natural barriers, as a result of which, it came to have certain features of its own.

There has been a continuous drift of population from villages to towns. Employment opportunities and educational facilities available in the towns are among the factors responsible for the drift in population to the towns. The towns have grown in importance as regards to communication, trade and commerce, industrialisation and the like. The urban life has become more complex. A large number of people in the urban areas are employees. The people in towns and cities depend upon rural people for food grains and raw material.

The life of people who live in rural areas is simpler and self-sufficient to a certain extent. They live close to natural surroundings and their life is more down to earth. Ecological practice being different, the village life is somewhat different from that of urban life but the quick means of transport have brought the rural and urban people into more frequent and closer contact.

Coastal Karnataka and Malnad area is richest in fishery resources and second richest in forest wealth in the state. The area receives heavy and reliable rainfall, and has vast extent of paddy fields, coconut, areca nut, cashew, cocoa, coffee, cardamom and tea and recently, rubber plantations. There is good sea-borne trade through six of its ports, a greatly improved transport system and the nearest air-port at Mangalore linking Bombay and Bangalore. Well-developed educational and training facilities at three local Universities -

Kuvempu University, Mangalore University and Manipal Academy of Higher Education, MAHE - a deemed University. Many small-scale and cottage industries and the best developed banking system (three major national banks of India were started as a local enterprise) have kept the economy of the region on a sound footing.

KUDREMUKH NATIONAL PARK

Baseline information

An attempt made here to collate and present information available in the existing literature and studies earlier carried out by research workers in the area. In this chapter short accounts of the status of biotic communities of the KNP area are presented. Major works by ecologists are quoted with components dealing with the geographic area dealt with under this paper. Works quoted in this chapter include Pascal J.P.(1988) and Daniels R.J.R(1989, 1990)

Geological outline

The geological formation of the central Western Ghats comprise of Pre-Cambrian rocks belonging to the Dharwar system. They are very rich in iron and manganese as well as copper, lead and gold. This system is well represented on the Karnataka plateau and it fans out from the Kudremukh region in three directions.

Bioclimate

The KNP environs experience the maximum rainfall recorded in the entire stretch of the WG range. Thus Agumbe, which is located at the northern boundary of KNP, receives mean annual rainfall of 7460 mm concentrated over a period of 128 days. The absolute maximum for Agumbe has been recorded as 12,918 mm in 1946. Surprisingly the elevation at Agumbe is only 645 m comparing to the Nilgiris (1500-2500m), which receives average rainfall of 6300 mm. Precipitation is about 4000 mm near the coast which increases steadily eastwards until reaching a maximum of 7500 mm in 40 km.

THE ENVIRONMENT

The Western Ghats forests comprising of Tungabhadra State Forest, the South Bhadra State Forest of the revenue district of Chikmagalur as well as the Naravi Reserve Forest and the Andar Reserve Forest of the revenue districts of Dakashina Kannada & Udipi (12°N and 16°N latitude) are now collectively designated as the "Kudremukh National Park"(KNP), under the control of Kudremukh Wild Life Division of the Karnataka State Forest Department.

The KNP has a total area of about 600 sq. km and is comprised of both lowland and highland tropical evergreen forests, shola-grassland-savanna and a mosaic of mixed semi-evergreen forests and plantations in the peripheral areas. The altitude ranges from 300 m in the lowlands to the highest peak of Kudremukh at 1892 m. The average altitude of the highland hills is about 1000m. The area receives good rainfall during monsoon months (June - October; Range: 1778-6350 mm, highest recorded in 1984 was 10,000 mm).

Precipitation and runoff regime is roughly defined at the crest of the ghat which also forms the western and eastern facies of the landscape. Thus the watershed west and south of the divide is very steep, contributing to rapid runoff of short-span river systems that drain into the Arabian sea. The watershed east and north of the divide caters to river systems that meander through gentler slopes and gullies and flow eastward towards the Bay of Bengal. Two major tributaries, the Tunga and the Bhadra originate from the dense Bhagavati forest. While Tunga flows due NNE towards Sringeri, Bhadra flows due east passing through the leasehold of the public sector enterprise - Kudremukh Iron Ore Company Ltd (KIOCL) mining area and joins up near Bhadravati town to form Tungabhadra river - and eventually merge with river Krishna.

Though in the past (1930's-40's) there had been some exploitation for timber, the forests of KNP have remained dense and undisturbed in the recent years, except for ill advised large scale monoculture plantations of exotics in some of the pristine climax savanna grasslands of the higher elevation. ***There are no so called "wastelands " in KNP except those that are created by human interventions***.

The area has no legally permanent human settlements, except for a few "tribal" communities who existed here for a long time. Even in the peripheries of the Park, particularly along its eastern and northern boundaries, the human population is sparse and widespread among plantations and small holdings of cultivated fields. Unlike the usual situation in other national parks and sanctuaries elsewhere, anthropogenic pressures on the vegetation for fuel and other needs is minimal in KNP. However, there have been recent cases of large scale encroachment of Park forests in the periphery by large, rich landholders for illegal extension of Coffee and other plantations. The KIOCL township is the only and the most populated human inhabitation in the KNP. The total human population of the township was estimated to be 10,636 (1991 Census). Though actual figures are not available, it is estimated that 350-450 privately owned cattle (mostly cows and a few buffaloes) exist in the Park area.

The Biodiversity Profile

The KNP is very rich in biodiversity. The vegetation is typical of the tropical evergreen forests. Though there are inventories and listing of prominent hardwoods, shrubs and herbs, no comprehensive data is available on the total plant species of the entire area. The plant species density and diversity of a selected representative sites is collated and presented, as also a list of endemic plants of the Western Ghats.

Inventories of animal and birds along with some data on their diversity, distribution and population status has been presented. Amphibians of the area were enumerated and their density and diversity was recorded. Over 35 species of amphibians and their density and diversity were recorded in the present study. Over 400 species of birds have been recorded for the KNP area. Of these, the present study recorded about 195 species of birds and their ecological distribution within the study area. Similarly data (from literature + field observations) on animals is collected and presented.

The KNP hosts 38 species of mammals belonging to 28 Genera. Four species are endemic to WG; these are the Liontailed Macaque(LTM - rare and endangered), the Nilgiri Langur (a northernmost range record for the species), the Malabar Civet and the Brown Palm Civet These are the Flagship species of the region. Some published data on the insects of the area was also collated and presented

Vegetation structure

Kadambi (1942) has distinguished 3 types in the *Poeciloneuron* forests of South Bhadra and Thunga Bhadra ,viz., "mixed evergreen", "semi-pure evergreen" and "pure evergreen" forests. They correspond to increasing concentrations of *Poeciloneuron*. Rai (1968) has studied the structure and primary productivity in South Bhadra RF corresponding to the gregarious *Poeciloneuron* facies.

Vegetation structure of two localities in the KNP are available. These are Suthanabi in Thunga Bhadra RF in a flat sheltered locality, to the west of ore mining site and below (750 m) the crest of the Ghats; and the other at Bhagavati in South Bhadra RF at an elevation of 900 m and west of mining site. These studies help in bringing out the variations within the same forest type .

SUTHANABI FOREST

The upper layer is almost continuous and is composed of trees whose heights vary between 25 and 39 m. There are no true emergents. Among the tallest trees are the 3

species characteristic of the facies, viz., *Poeciloneuron indicum, Palaquium ellipticum* and *Hopea ponga. Poeciloneuron is* also present among the shorter trees of this layer. This species is remarkable for its strong' intertwining stilt roots which perform the same role as the buttresses of *Hopea ponga* and *Palaquium ellipticum.* As this forest is sheltered from wind, this is probably an adaptation to excessive soil moisture during the rainy season. The rainfall is more than 5000 mm on a fairly flat topography.

Poeciloneuron indicum (27.6%), *Palaquium ellip*ticum (10.4%) and *Hopea ponga* (7.8%) are the most common tall trees. The undergrowth is dominated by *Cleistanthus malabaricus* and *Meiogyne pannosa* (10.4% each). These 5 species constitute 66.7% of the trees. Dipterocarpaceae is represented by *Hopea ponga* and not by *Dipterocarpus* as in the low elevation types.

BHAGAVATI FOREST

The rainfall here is more than 7000 mm.

The top story is monospecific, composed of *Poeciloneuron indicum* which forms a continuous layer without emergents. The height of the stand varies between 24 and 30 m. The trees are slightly taller as we descend into the valley where they are more sheltered. The influence of wind is very clearly seen in the orientation of the branches in trees that are nearest the crest. The foliage is generally concentrated in the upper part of the trees except for a few smaller individuals where reiteration is not yet profuse. The base of the trees shows intertwining stilt roots characteristic of this species; they are very well developed on the side away from the slope.

List of the important endemic species of the evergreen forests of the Western Ghats
(Source: Pascal. 1988)

FAMILY	SPECIES
DICOTYLEDONS	
Anacardiaceae	*Holigarna arnottiana, Holigarna grahamii, Gluta travancorica, Nothopegia travancorica*
Annonaceae	*Goniothalamus cardiopetalus, Meiogyne pannosa?, Polyalthia fragrarls*
Burseraceae	*Canarium strictum*
Celastraceae	*Euonymus indicus*
Clusiaceae	*Calophyllum apetalum, Garcinia indica, Garcinia talbotii, Poeciloneuron indicum*
Cornaceae	*Mastixia arborea*

Dipterocarpaceae	*Dipterocarpus bourdillonii, Dipterocarpus indicus, Hopea parviflora, Hopea ponga, Hopea utilis, Vateria indica*
Ebenaceae	*Diospyros assimilis, Diospyros bourdillonii, Diospyros foliolosa, Diospyros nigrescens, Diospyros paniculata*
Euphorbiaceae	*Baccaurea courtallensis, Blachia denudata, Cleistanthus malabaricus, Dimorphocalyx lawianus, Drypetes elata, Drypetes malabarica, Mallotus beddomei, Mallotus stenanthus*
Fabaceae	
Caesalpinioideae	*Bauhinia phoenicea, Humboldtia brunonis, Humboldtia unijuga, Humboldtia vahliana, Kingiodendron pinnatum*
Faboideae	*Ormosia travancorica*
Flacourtiaceae	*Casearia bourdillonii, Hydnocarpus laurifolia*
Lauraceae	*Actinodaphne malabarica, Apollonias arnottiana, Beilschmiedia wightii, Cinnamomum malabathrum, Litsea bourdillonii, Litsea floribunda, Litsea oleoides, Litsea stocksii*
Melastomataceae	*Memecylon malabaricum, Memecylon talbotianum*
Meliaceae	*Aglaia anamallayana, Amoora canarana, Dysoxylum ficiforme, Dysoxylum malabaricum*
Moraceae	*Artocarpus heterophyllus, Artocarpus hirsutus*
Myristicaceae	*Knema attenuata, Myristica fatua var. magnifica, Myristica malabarica*
Myrtaceae	*Syzygium laetum*
Olacaceae	*Anacolosa densiflora*
Oleaceae	*Linociera malabarica*
Rubiaceae	*Ixora brachiata, Ixora elongata, Lasianthus acuminatus, Psychotria dalzellii, Psychotria flavida, Psychotria truncata, Saprosma fragrans, Saprosma glomerata, Tricalysia apiocarpa*
Rutaceae	*Vepris bilocularis*
Sapindaceae	*Otonephelium stipulaceum*
S apotaceae	*Palaquium ellipticum*
Staphyleaceae	*Turpinia malabarica*
Sterculiaceae	*Heritiera papilio, Leptonychia moacurroides*
Theaceae	*Gordonia obtusa*

MONOCOTYLEDONS

Arecaceae	*Arenga wightii, Pinanga dicksonii(?)*
Poaceae	*Ochlandra beddomei, Ochlandra scriptoria, Ochlandra travancorica*

The extensive lowland forests comprising of Naravi RF and Andar RF and the adjacent Someshwara wildlife Sanctuary are included under the KNP. These forests comprise mainly of tropical evergreen and moist deciduous types. Some areas have been extensively planted with teak (*Tectona grandis*).

Amphibian fauna

It is becoming increasingly apparent over the world in general and tropical countries in particular, that large scale alteration of habitats - whether they are forests, deserts, scrublands, grasslands, wetlands or estuaries - leads to a greater loss of biodiversity.

One of the ways to estimate the rate of loss and to take appropriate mitigating measure to minimise these loss is to look at the status of the indicator species that inhabit the area. Among the apparent and most sensitive components of the ecosystem are the amphibian species which are sensitive enough to indicate the status of the environment that they occur in. The study and knowledge of the changes occurring in the amphibian communities over a period in a given area gives us an understanding and insight into the problem.

The Western Ghat belt is known to offer the most congenial microhabitats for several endemic varieties of amphibians. This has been evidenced by recent calculation on amphibian diversity in BCPP CAMP 1997 (Sanjay, 1997). According to this report, out of 207 Indian amphibians nearly 60% (125 species) are confined to Western Ghats. Further, out of these 125, about 93 species are strictly endemic to Western Ghats.

Krishnamurthy (this volume) gives details of the amphibian diversity recorded from Kudremukh National Park, surroundings of Sringeri and Lakkavalli State Forest regions of Western Ghats. Over the period of his study, 35 + species of amphibians (including 5 species of apodans) were recorded each from Sringeri and Kudremukh National Park, while 20 + species (including 2 species of apodans) were recorded from Lakkavalli State Forest.

The study was carried out in three selected locations viz., Kudremukh National Park (Bhagavathi and Gangadikallu gudda forests), environs of Sringeri town and periphery of Lakkavalli State forests near Kuvempu University. Survey and collection of amphibians was made between 1990-94 in the environs of Sringeri, while the observation and recording of amphibian species, habitat and distribution pattern are still in progress since June 1996 in Kudremukh National Park and periphery of the Lakkavalli forest region.

Amphibian fauna of this region belonging to two orders viz., Anura and Apoda, comprises four and two families respectively. Among the anurans, the members of the family Ranidae predominated (49%) both by number of species and occurrence. The predominating species among Ranidae are Rana (14 Species) while the order Apoda comprises two families, viz., Ichthyophidae and Uraeotyphlidae. The former is dominated by the members of genus Ichthyophis, while the latter is represented by only one species, *Uraeotyphlus narayani*. Common habitat preferred by maximum number of Ranids was aquatic, while the Rhacophoridae and Bufonidae strictly confined to arboreal and terrestrial habitat respectively. However, most forms of Apoda, (both Ichthyophidae and Uraeotyphlidae, and a few forms of Anura (members of Ranidae) share the habitat or confined to semiaquatic to terrestrial habitats.

Totally, there are 21 species which fall under Lower Risk Near Threatened (LRNT) followed by 7 species of Vulnerable (Vu), 4 species belonging to Lower Risk Least Concern (LRLC) and 3 species of endangered (EN) in nature. Under LRNT, again the Ranids predominate with Rana 9 species, Nyctibatrachus, and Tomopterna one species each. The vulnerable species recorded in this study are among Ranids: *Rana tigerina, R. limnocharis, R. beddomei and R. semipalmata* ; among Apoda, *Ichthyophis beddomei. I. malabarenis* and *Uraetyphlus narayani*. The endangered are two species of Ichthyophidae- *I. bombayensis* and *I. tricolor* and a species of Ranid - *Nyctibatrachus sanctipulustris*.Totally, among the whole of amphibian diversity recorded, 21 species were strictly endemic to Western Ghats, in which the Ranids predominate (10 species) followed by members of the order Apdoa (5 species).

Threats to amphibians: Many significant threats to the amphibians of Karnataka were described by Daniels (1992). In the present study also, some important threats were recorded. However, the threats and the ultimate target species differed in different study locality. In the study sites of Kudremukh National Park, the threats as such for amphibian species are not noticed in the undisturbed forests. However, areas of human influence, particularly, mining activities appear to affect amphibian fauna badly. Around Sringeri, and in the periphery of Lakkavalli state forest, the agriculture related habitat alteration, use of chemicals , fertilizers and pesticides are posing considerable problem to amphibian species. Monoculutred plantations, except during the rainy season, do not support amphibian diversity.

In the Western Ghats the amphibian population is under the threat from man-made habitat alteration, particularly denudation of forests, mining and other agriculture related activities. (Daniels, 1992; Krishnamurthy, 1996).

Insect fauna

Western Ghats are important in view of their genetic heterogeneity and species diversity. Unfortunately, very little is known about insects of this area. Many workers have drawn a check-list of groups of insects in small areas in Western Ghats region. There is no published data on the insects of KNP. A few, random examples of insect studies of the area is given below.

Some workers have sampled insects as a whole from study areas in Western Ghats. Gadagkar et al. (1993) collected 140 species ants from 12 localities in Western Ghats by a combination of quantitative sampling methods and all-out search. The forests in Western Ghats have very rich and highly diversified soil insect fauna. A sampling of micro, meso and macro-fauna in four habitats, viz. less distributed forest, afforested land, deforested land grassland along National Highway No.48 from Sakleshpur to Uppinangadi revealed that ants, termites, collembola, psocids and carabids, were abundant in less disturbed forests (Rajagopal, 1993). Rajagopal (1991) conducted detailed studies on soil insects to include Collembola (20 species), Oribitid (930 species), Mesostigmata (16 species), ants (50 species), termites (15 species), carabid beetles (50 species), etc. from Western Ghats.

Rajagopal (1991) recorded 60 species of ants from Shiradi Ghats section, at four altitudes, Sakleshpur in Hassan to Uppinangadi in Dakshina Kannada district. These 60 species were distributed in 31 genera and six subfamilies of Formicidae. Based on frequency of occurrence and number of altitudes ants occurred, 15 species were categorized as rare and 16 species as endemic. Ali (1991 and 1992) reviewed the worksof 41 workers on ant fauna of Karnataka and listed 125 species.

Satish (1996) recorded 13 species of moths and 16 species of butterflies from 3 km^2 area of the campus of Kuvempu University, Shimoga in one year. The western ghats are a focal point of endemic biodiversity of butterflies, especially *Colias hyale*. It is a endemic species listed under Indian Wildlife Protection Act, (1972) and it merits conservation status. Harish Gaonkar (1996) has listed 330 species of butterflies from the western ghats.

Rajagopal (1991) recorded 40 carabid beetles in different habitats at four altitudes from Western Ghats along National Highway No.48. Carabids were encountered at Nellyadi (26), Sakleshpur (12), Hongarahalla (9) and View point (6). Lower altitude recorded more number of species than habitats at higher altitudes. *Omphra pilosa* and Tachys sp. were found distributed at all the altitudes while *Diplocheila polita* was recorded in all the three altitudes except at 170m.

All the four species of *Pheropsophus* were encountered only at higher altitude in Sakleshpur (940 m). Tiger beetles belong to family Cicindellidae and these are predatory in nature. These are brightly coloured beetles with long legs. Twenty-four species (larvae) were found at different habitats from Sakleshpur to Uppinangadi... Chakravarthy collected 19 species of Scarabaeid beetles in 3 months (June to August) from Madenur, Hassan in 1996 and 1997.

Avifauna

The factors which determine diversity and assemblages of birds are the rainfall regime, habitat types, landscape heterogeneity, vegetation structure and floristics. The other factors that essentially affect the movements of birds are the food availability and disturbance to their habitat. Habitat fragmentation and its eventual loss affects bird communities in a general way. It is estimated that habitat loss and alteration affects over 51% of the world's bird species and of the birds with endangered status over the world, 73% are forest & scrubland species

Ornithology of the region

Considerable amateur and professional studies relating to birds, their distribution, some aspects of biology and migration have been undertaken in the Indian sub-continent (Ali & Ripley 1983). In the recent years there have been additional studies initiated by the Bombay Natural History Society (BNHS) and other individual ornithologists on the ecology of certain species of birds of the region. Some data on migration, biometrics, seasonality and distribution was collated by the field studies carried under the BNHS Bird Migration. However, there have been major gaps in the study of community ecology of Indian birds, particularly that of the tropical forest birds.

Avifauna of tropical forests.

Forest birds of southern Western Ghats (WG) including that of north-east India form a small fraction of the avifauna of the entire sub-continent. There have been a few recent studies on tropical forest birds of the southern WG (Khan, 1977 ; Vijayan L.,1984.; Islam M.A., 1985; Kannan R.1994). However these studies were basically species specific. The only recent major and detailed study on the bird community structure and the impact of habitat alteration by human activities on the avifauna of the region was done by R.J.R. Daniels in the Uttara Kannada district (including the lowland and highland forest tracts of the WG) of Karnataka (Daniels,1984).

Kudremukh National Park (KNP)

From the distributional range given in the available literature it appears that the total number of bird species occurring in the region could be 400 ± 20 . The total number of species recorded in the KNP over a period of one year is 195 . These were based on actual sightings in the highland/ lowland forests as well as the secondary forests and urban areas of the coastal belt. The tropical forests of southern WG (including the coastal areas) harbour a lower diversity of bird species in comparison to similar habitats of African and Neotropical forests. Daniels(1984) estimated that in the evergreen forests of the south-western India a maximum of 150 species of birds are present in an area less than 15 km^2, whereas 478 species have been recorded in Ecuador (S. America) and 365 species in Gabon (Africa).. The recent rapid changes in the landscape may have caused the disappearance of some species while some others may have recently colonised the changed habitats.

The flagship species of the tropical forest birds which are either endemic to the southern WG or have a patchy distribution of small populations, are represented in KNP region by Great Hornbill (*Buceros bicornis*), Nilgiri Wood Pigeon (*Columba elphinstonii*), Wynaad Laughing Thrush (*Garrulax delesserti*), Jerdon's Laughing Thrush (*G. jerdoni*), Bluewinged Parakeet (*Psittacula columboides*), Greyheaded Bulbul (*Pycnontus priocephalus*), Southern Tree Pie (*Dendrocitta leucogastra*), Whitebellied Blue flycatcher (*Muscicapa pallipes*) and Nilgiri Flycatcher (*Muscicapa albicaudata*). Some other species such as Black Eagle (*Ictninaetus malayensis*) and Ceylon Frogmouth (*Batrachostomus moniliger*) may also occur.

Discussion

Daniels(1984) divided his study area into five avifaunal zones based on diversity and similarity in the birds in relation to rainfall and vegetation. The zones comprised of a) evergreen, b) disturbed evergreen, c) moist deciduous, d) dry deciduous and e) coastal. He then carried out census 107 transects of 600 m length in 15 major habitat sites for over a period of two years. His results showed that:

- The structurally more complex evergreen forests have 31 taxa per sample whereas it is 33 in the degraded forests and 47 in the moist deciduous forests.
- Structurally similar vegetation types have similar assemblage of birds
- Samples from localities within 25 km^2 are 40% similar if belonging to same habitat and 25% if from different habitats.

He further concluded that as a habitat, the evergreen forests maintain the geographically most restricted birds (= habitat specialist) and secondary forest birds are widespread (= habitat generalists) with respect to habitat use. The study recommended that by preserving evergreen forests, geographically most restricted bird species/populations can be preserved. For maintaining high species diversity, a combination of evergreen and moist deciduous forests, secondary woodlands in urban areas and freshwater marshes are essential.

Bird species assemblages have been characterised in terms of numbers of individuals or various measures of diversity such as species richness or evenness. Sets of such assemblages can be characterised in terms of how widespread their constituent species are and how similar the assemblages are. Pramod *et al* ,(this volume) defined the measures of these properties termed ubiquity and hospitabilty. They explored the distribution of these two parameters for a set of 132 bird assemblages censused with the help of one hour long transects of 100 x 600 m in 21 localities covering 9 major habitat types from across the entire Western Ghat hill range. The result obtained indicate that biological parameters characterising individual transects are positively correlated with each other, and physical parameters such as rainfall and latitude form yet another independent group of positively correlated parameters.

In other words, montane evergreen forests and monoculture plantations both harbour species poor communities. However, those of montane evergreen forests are cohesive assemblages of restricted geographic distribution (= habitat specialists), while those of monoculture comprise species of widespread occurrence drawn from many different habitat types(= habitat generalists). This supports Daniels(1984) finding as mentioned above. This also suggests that, eventhough it would appear to be advantageous to maintain "mosaic" type of habitat to increase the bird species diversity of an area, it is absolutely essential to maintain large evergreen patches for the survival of the habitat specialists

The limited studies carried out in Kudremukh area shows that highest bird species diversity occurs in the habitat consisting of a mosaic of evergreen patches, secondary scrub, marginal shola -like patches between mixed crop plantations (which consist of Areca, Cardamom, Pepper, Coffee and fruit trees). Undisturbed closed canopy primary evergreen forest patches hosted habitat specialists in the dense sholas and mixed hunting parties in the more open edges. Shola grasslands with monoculture plantations were very poor in diversity - here even the grassland habitat specialists were conspicuous by their absence.

Though the KIOCL mining sector is devoid of any species, surprisingly small patches of remnant shola forests within the actual mining area harboured small populations of habitat

specialists. Kudremukh township with a mosaic of urban ornamental plantations and intermingling with patches of dense secondary scrub hosts yet another diverse bird populations. Lowland forests of KNP host a good species assemblage typical of the area.

A quick analysis of census carried out at Kudremukh National Park (including mining area)
Two censuses were carried out at each site

Sampling Site	Altitude Range From MSL	Distance From CORE mining area	Habitat/ Vegetation	No. of species recorded	Habitat specialist species
Mining Site	800-1000	–	Highly disturbed open grassy hills plus small shola patches	12	3
Kudremukh Township	700-800	500	Urban area with plantation and gardens	32	0
Samse Village	800-1000	5 km	Mosaic of plantation, shola and scrub	26	2
Gangrikal	800-1500	8 km	Shola and Grasslands	22	5
Lakya dam, backwaters	900-1000	3 km	Water reservoir surrounded by grasslands and monoculture plantations	6	0
Naravi Forest	300-600	15 km	Dense lowland forests	36	4
Horanadu	800-900	15 km	Deciduous scrub. Rain shadow area	6	0

Mammals

In the KNP area endemics are represented by Primates (2 spp.), and small Carnivores (2). Except the Nilgiri Tahr (*Hemitragus hylocrius*), all other endemics of the WG are found here. The KNP hosts perhaps the single largest population of the flagship species, the Liontailed Macaque (LTM), north of Silent Valley in Kerala. It is estimated that over 200-300 occur in the KNP belt and a few other small populations scattered in the lowland forests of Someshwara and Mookambika W/L sanctuaries located north of KNP.

Number of Genera and Species and endemic mammals in KNP.

Mammal groups	Genera	Species	Endemic
Primates	3	5	2
Large carnivores	1	2	-
Small Carnivores (Felids)	1	4	-
Small Carnivores (other)	4	7	2
Canids	3	3	-
Mustelids	2	3	-
Rodents	5	5	-
Deers	4	4	-
Other species	5	5	-
Total	**28**	**38**	**4**

Nilgiri Langurs (*Trachypithecus johnii*) have been recorded during this study which is an extension of northern range of the species. The other species recorded recently is the rare and endangered Malabar Civet (*Viverra civettina*), small populations of which have been frequently reported from Mookambika, Someshwara W/L sanctuaries as well as lowland and highland forests of KNP.

The Indian Gaur (*Bos gaurus*) is the largest common ungulate occurring in both lowland and highland forests of KNP, followed by Sambar (*Cervus unicolor*) and Chital (*Axis axis*) . These are the commonest animals of the area. However, large-scale forest clearings for agriculture and human settlements in the past 100 years, particularly the lowland forests, has fragmented their populations into smaller herds, frequently bringing them into conflict with human settlements. The populations of their natural predator, the Tiger (*Panthera tigris)* is also drastically reduced due to anthropomorphic pressures. As everywhere else in the region, the Leopard (*P. pardus*) is still holding on its own, particularly in the secondary mixed forests and mosaic vegetation.

No comprehensive studies have been attempted by any ecologists on the mammalian fauna of KNP and as such no published literature is available on this subject. However, some information was gathered from local inhabitants and forest personnel as well as direct observations made by the field team.

It is estimated that over 150 LTM are present in the KNP. Most of these are confined

to heavy rainfall areas of Shola/Grasslands of Bhagavati forest, Tungabhadra state forest (Kerekatte) and steep western slopes of the ghats and lowland forests of Andar Reserve and Naravi Reserve forests (above 200 m MSL). A total of ten troops were encountered by the field party. These are listed below:

Site	Habitat	No. of troops	No. of individuals/ troop
Gangrikal shola complex	Shola/grassland	4	14, 8,10 & 9
Kadambi/Bhagavati	Evergreen	2	8 and 7
Kerekatte	Evergreen	3	12, 11 and 9
Agumbe	Evergreen	1	10
	Total	**10**	**98**

The animals are less shy and allow approach and observation. The figures given above enumerated from chance encounters while reconnoitering the area. It is possible that more animals can be detected by a regular search.

The occurrence of the Nilgiri Langur was recorded (needs further confirmation) during this study. This is a range extension for the species which may have been overlooked so far by earlier workers. The known northern limit of the range is upto Coorg. The animals are very dark with pale brown head, characteristic of the species and are confined to dense highland forests of KNP. Lowland forest Langurs are pale gray.

Elephants (*Elephas maximus)* are very rare in KNP. However, there have been occasional individuals straying in the periphery of the Park. It is interesting to note that elephants occur both north and south of but not in KNP. Several species of bats occur both in highland and low land forests.

Conclusions & recommendations

The Western Ghats of Karnataka possess some of the most pristine lowland and highland forests in the entire WG chain. Though these forests have gradually been fragmented into smaller disjointed stretches of evergreen, moist evergreen, moist deciduous, mixed scrub, and regenerating woodlands, the diversity of mammalian fauna still holds out on its own in smaller pockets. Transitional belt of lowland forests of coastal

zone, highland forests of steep hill slopes culminating in specialised vegetation of hill crest which then gradually stretch eastwards into rolling mosaic of forests mingled with plantations, host a number of species including some rare endemics. The rich wildlife of the area is underscored by the fact that two national Park and several wildlife sanctuaries have been in existence straddling the WG.

However, as is happening all over the developing countries of the tropics, there are many problems faced by the KNP ecosystem. Anthropogenic pressures are felt in the peripheries of the park. Encroachment of forest land by marginal farmers, large plantations as well as cattle grazers is a serious problem. The major activity in the Park ecosystem is of iron ore mining by the pubic sector Kudremukh iron Ore Company (KIOCL). A brief assessment of the problems faced in the KNP are as follows:

- The hills in the immediate vicinity of KIOCL mining area and downstream flow of Bhadra river immediately after its passage through mining town, are affected to a significant level by the - mining operations. The down stream impact will be an *ex situ* problem and will lead to cumulative long-term effect on the biodiversity of Bhadra river ecosystem.

- In the name of "aforestation" large scale monoculture plantation of exotics in the grasslands - which are mistakenly considered as "wastelands" and "degraded lands" - by Forest Dept in the past has led to considerable loss of biodiversity of pristine climax savanna grasslands of the KNP ecosystem.

- The presence of considerable number of domestic cattle will not only pose stiff competition for prime grazing sites (which are, already affected by ill-advised plantations) for wild ungulates, particularly during drier months, but also expose them to the risk of cattle diseases.

Recommendations

- Immediate measures should be taken to contain top soil run off from KIOCL mining site into Bhadra river, particularly in the early monsoon months. These can be instituted by mechanical, physical or biological means. The field team came across particular indigenous species of herbs regenerating very successfully in the disturbed loose soil mined area. Research studies should be instituted to cultivating these shrubs in the mining area as a soil binder.

- Plantation of all monoculture exotics in the savanna grasslands and other areas of the mining lease as well as the KNP should be stopped. The existing plantations should be removed (only if allowed to do so) and not replant the area if they perish due to some reason or other. Make sure that the grass species re-establish themselves in the area.

- Enumerate the cattle population in the area and take measures to immunise/mark them against diseases. If possible shift them to an area outside KNP.

- The KNP forests are presently stabilised due to protection accorded under Forest Act. There is no immediate need to carry out "aforestation" to cover so-called "degraded" forests, "barren" hills or "wastelands". Allow the forests and grasslands to regenerate by natural process. It is essential to provide adequate protection and monitor the growth scientifically.

- Constantly monitor the forest/grassland ecosystem to detect, contain and eradicate alien exotic and weed species invasion and colonisation.

- Encourage and support field research for assessing the biodiversity potential of the KNP and provide necessary help to establish a long term multidisciplinary Research Program involving filed scientists from NGO's, Universities and Wild Life Dept.

- Provide help and assistance to KNP authorities in protection and maintenance of the forests and its biodiversity.

- Assist appropriate agencies in educating the public about the importance and values of the biodiversity of the Tropical Evergreen Forests.

Acknowledgements

The authors gratefully acknowledge the support, assistance and help provided by - The Bombay Natural History Society, Mumbai; Kudremukh Wildlife Division of the Karnataka State Forest Department and the administration of the Kudremukh Iron Ore Company, Malleshwara.

References

Ali, Salim., and Ripley, S.D.R., 1983. A Handbook of the birds of India and Pakistan 10 Vols. Oxford University Press. Bombay.

Daniels, R.J.R. 1984 Bird communities of Uttara Kannada. Ph.D Thesis

Daniels, R.J.R. 1992. Geographical distribution of Amphibians in the Western Ghats, India. *J.Biogeogr.* 19: 521-529.

Daniels, R.J.R. 1992. The Amphibian fauna of Karnataka. What does it suggest. Karnataka State Environment report V.79-85.

DeBach, P. 1974. Biological Control by natural enemies. New York: Cambridge University Press.

Gadagkar, R., Chandrashekara, K. and Nair, Padmini, 1990. Insect species Diversity in the Tropics: Sampling Methods and a Case Study. J. Bombay Nat. Hist. Soc., 87(3) : 337 - 353.

Gadagkar, R. Nari P. and Chandrashekar, K. 1993. Ant Species Richness and Diversity in some Selected Localities in Western Ghats, India. Hexapoda 5(2) : 79-94.

Gaonkar. H., 1996 The Butterfly Fauna of the Western Ghats, India and Sri Lank: A Biodiversity Assesment.

Islam, M. A. 1985 Ecoogy of the Laughing Trushes of India with Special Reference to Endemic Species. Ph.D Thesis. Bombay University.

Kadambi, K. 1942 The Evergreen Ghat Rain Forests of the Tunga and Bhadra River Sources (Part-I). *Indian Forester.* 68(5):233-240.

Kadambi, K. 1942 The Evergreen Ghat Rain Forests of the Tunga and Bhadra River Sources (Part-II). *Indian Forester.* 68(6): 305 - 302.

Kanna. R. 1994. Ecology and Conservation of the Great Pied Hornbill *(Buceros Bicornis)* in the Western Ghats of India. Ph.D. Thesis.

Khan. M.A.R. 1977. Ecology and Behaviour of the Black - and- orange Flycatcher *Muscicapa nigorufa,* Ph.D. Thesis. Bombay Unviersity.

Krishnamurthy, S. V. and Katre, S. 1993. Amphibian Fauna of Sringeri Taluk. J. of Indian *Science* 73:443-452.

Krishnamurthy S. V. 1996 Future of Some Anurans in the Malnad Region of Western Ghats. *Zoos Print.* XI (5): 9-11.

Krishnamurthy S. V. (this volume). Amphibian Biodiversity in a few Selected Environs of Western Ghats.

Musthak Ali, T. M. 1991. Ant Fauna of Karnataka - I. Newsletter of IUSSI Indian Chapter. 5(1&2) : 1-8.

Musthak Ali, T. M. 1992. Ant Fauna of Karnataka - II. Newsletter of IUSSI Indian Chapter. 6(1&2) : 1-9.

Pascal, J. P. 1988. Wet Evergreen Forests of the Western Ghats of India: Ecology, Structure, Floristic Composition and Succession. *Institut Francais de Pondicherry.*

Prasad Kumar U. K. and Viraktamath, C. A. 1991. Illustrated keys for identification of common Species of Short-horned Grasshoppers of Karnataka and Notes on their Ecology and Behaviour. Hexapoda, 3(1&2) : 53-70.

Rai. S. N. 1981. Productivity of Tropical Rain Forests of Karnataka. Ph.D., Thesis. Bombay

Rajagopal, D. 1991. Annual Report. Studies on the Soil Fauna, thier Diversity and Relationship to the Ecosystem in Western Ghats. Mimeographed. pp 17..

Rajagopal, D. 1991. Annual Report. Studies on the Soil Fauna, thier Diversity and Relationship to the ecosystem in Western Ghats. Mimeographed. pp 48..

Sanjay, M. 1997. All Indiaan amphibians assessed according to the new IUCN categories. Frog Log 2.(1) : 5-6.

Satish, P. M. 1996 Moths and Butterflies of Bhadra Reservoir. M. Sc. Thesis. Kuvempu University.

Vijayan L. 1984 Comparative biology of Drongos with reference to ecological isolation. Ph.D Thesis. Bombay university

CHECKLIST OF BIRDS OF KUDREMUKH NATIONAL PARK, INCLUDING LOWLAND FORESTS, SECONDARY SCRUB AND COASTAL BELT OF UTTARA KANNADA, DAKSHINA KANNADA & UDIPI DISTRICTS ENVIRONS

*** = Species recorded in Kudremukh National Park.**

Species	Status	Niche	Habitat
Podicipitidae			
Little Grebe *Dachybaptus ruficollis*	R/LM	10	LF/HF/CB
Phalacrocoracidae			
Large Cormorant *Phalacrocorax carbo**	LM/AM	9/10	LF/HF/CB
Little Cormorant *P. niger**	LM/AM	9/10	LF/HF/CB
Darter *Anhinga rufa**	BV/LM	9/10	LF/HF/CB
Ardeida			
Grey Heron *Ardea cinerea*	LM	10/14	CB
Purple Heron *Ardea purpurea*	LM	10	CB
Little Green Heron *Ardeola striatus* *	LM	10	CB
Large Egret *Ardea alba* *	BV/LM	9/10	LF/HF/CB
Pond Heron *Ardeola grayii* *	BV/LM	9/10	LF/HF/CB
Cattle Egret *Bubulcus ibis**	BV/LM	10/11	LF/HF/CB

Status: R= Resident; BV= Breeding visitor; LM= Local migrant; WM= Winter migrant; AM= Altitudinal migrant; O= Occasional; St=straggler; X= Rare

Niche : 1= Dense forest; 2= Open forest; 3=Secondary scrub; 4= Shola forest; 5= grassland; 6= mosaic vegetation#; 7= Exotic plantation; 8= village/township; 9= river; 10= wetland; 11= Cultivation; 12= Plantation/orchard. 13 = sea shore; 14 = Magroves & backwaters;

LF = Lowland Forest; HF = Highland Forest; CB= Coastal belt

Multi-species plantation interspersed with natural forests, sholas etc in the periphery of the Park.

Species	Status	Niche	Habitat
Intermediate Egret *Egretta intermedia*	BV/LM	10/11	LF/HF/CB
Little Egret *Egretta garzetta**	BV/LM	10/11	LF/HF/CB
Reef Heron *Egretta gularis*	LM	10/14	CB
Night Heron *Nycticorax nycticorax**	R/BV	10	CB
Tiger Bittern *Gorsachius melanolophus*	R	9/10	LF/HF/CB
Chestnut Bittern *Ixobrychus cinnamomeus**	R	9/10	LF/HF/CB
Ciconiidae			
Whitenecked Stork *Ciconia episcopus*	LM	9/10	LF/CB
Threskiornithidae			
White Ibis *Threskiornis aethiopica*	LM	9/10	CB
Anatidae			
Lesser Whistling teal *Dendrocygna javanica**	BV/LM	9/10	LF/HF
Cotton Teal *Nettapus coromandelianus*	BV/LM	9/10	LF/CB
Common Teal *Anas crecca*	WM	9/10	CB
Accipitridae			
Blackwinged Kite *Elanus caeruleus**	R	3/5/6	LF/HF
Blyth's Baza *Aviceda jerdoni**	LM/O	1/4	LF/HF
Black-crested Baza *A. leuphotes**	LM/O	1/4	LF/HF
Honey Buzzard *Pernis ptylorhynchus**	LM	2/3	LF/HF
Pariah Kite *Milvus migrans**	R	2/3/8	LF/HF/CB
Brahminy Kite *Haliastur indus**	R	2/3/8	LF/HF/CB
Goshawk *Accipiter gentilis**	R	2/3	LF/HF
Shikra *Accipiter badius**	R	2/3	LF/HF
Besra Sparrowhawk *Accipiter virgatus**	R	1/4	LF/HF

Species	Status	Niche	Habitat
White-eyed Buzzard *Butastur teesa*	R	2/3	LF
Hodgson's Hawk eagle *Spizaetus nipalensis**	R	1/4	HF
Crested Hawk eagle *S. cirrhatus*	LM	2/3	LF
Rufousbellied Hawk eagle *Hieraaetus kienerii**	LM	1/2/4	HF
Black eagle *Ictinaetus malayensis**	LM	1/2/4	LF/HF
Whitebellied Sea eagle *Haliaeetus leucogaster*	R	13/14	CB
Marsh Harrier *Circus aeruginosus*	WM	10/14	CB
Serpent eagle *Spilornis cheela**	R	2/3/6	LF/HF
Osprey *Pandion haliaeetus*		WM	10/14 CB
Kestrel *Falco tinnunculus**	R	3/5	LF/HF
Phasianidae			
Rain Quail *Coturnix coromandelica**	R	3/5	LF/HF
Jungle Bush Quail *Perdicula asiatica**	R	3/5	LF/HF
Rock Bush Quail *Pardicula argoondah*	R	3/5	LF
Painted Bush Quail *Perdicula erythrorhyncha**	R	3/5	HF
Button Quail *Turnix sylvatica**	R	3/5	LF/HF
Grey Partridge *Francolinus pondicerianus*	R	3/5	LF
Red Spurfowl *Galloperdix spadicea**	R	3/5	LF
Grey Junglefowl *Gallus sonneratii**	R/AM	2/4/5	LF/HF
Peacock *Pavo cristatus**	R/AM	2/4/5	LF/HF
Banded Crake *Rallina eurizonoides**	LM/AM	1/6	LM
Ruddy Crake *Porzana fusca**	LM	1/6	LF/HF
Brown Crake *Amaourornis akool**	R	3/10	LF/HF/CB

Species	Status	Niche	Habitat
Whitebreasted Waterhen *Amaurornis phoenicurus**	R	3/10	LF/HF/CB
Moorhen *Gallinula chloropus*	R	10	LF/CB
Purple Moorhen *Porphyrio porphyrio*	R	10	LF
Coot *Fulica atra*	LM	10	CB
Jacanidae			
Pheasant-tailed Jacana *Hydrophasianus chirurgus*	LM	10	LF/CB
Bronzewinged Jacana *Metopedius indicus*	LM	10	LF
Charadrinae			
Redwattled Lapwing *Vanellus indicus**	R	3/11	LF/HF/CB
Yellow-wattled lapwing *Vanellus malabaricus*	R	3/11	LF/CB
Grey Plover *Pluvialis squatarola*	WM	13/14	CB
Eastern Golden Plover *Pluvialis dominica*	WM	13/14	CB
Large Sand Plover *Charadrius leschenaultii*	WM	13/14	CB
Little Ringed Plover *Charadrius dubius*	LM	10/14	LF/CB
Kentish Plover *Charadrius alexandrinus*	WM	10/14	CB
Lesser Sand plover *Charadrius mongolus*	WM	13/14	CB
Whimbrel *Numenius phaeopus*	WM	13/14	CB
Curlew *Numenius arquata*	WM	13/14	CB
Blacktailed Godwit *Limosa limosa*	WM	13/14	CB
Bartailed Godwit *Limosa lapponica*	WM	13/14	CB

Species	Status	Niche	Habitat
Scolopacinae			
Common Red shank *Tringa totanus*	WM	10/14	CB
Marsh Sandpiper *Tringa stagnatilis*	WM	10/11	CB
Common Greenshank *Tringa nebularia*	WM	10/14	CB
Wood Sandpiper *Tringa glareola*	WM	10/11	CB
Common Sandpiper *Tringa hypoleucos*	WM	10/11	LF/CB
Turnstone *Arenaria interpres*	WM	13/14	CB
Common Snipe *Gallinago gallinago*	WM	10/11	CB
Little Stint *Calidris minuta*	WM	13/14	CB
Curlew Sandpiper *Calidris testacea*	WM	13/14	CB
Ruff & Reeve *Philomachus pugnax*	WM	10/11	CB
Painted Snipe *Rostratula benghalensis*	LM	10/11	CB
Blackwinged Stilt *Himantopus himantopus*	LM	10/11	CB
Small Indian Pratincole *Glareola pratincola*	LM	10/11	CB

Species	Status	Niche	Habitat
Laridae			
Herring Gull *Larus argentatus*	WM	13/14	CB
Lesser Blackbacked Gull *Larus fuscus*	WM	13/14	CB
Brownheaded Gull *Larus brunnicephalus*	WM	13/14	CB
Blackheaded Gull *Larus ridibundus*	WM	13/14	CB
Whiskered Tern *Chlidonias hybrida*	LM	10/14	CB
Gullbilled Tern *Gelochelidon nilotica*	LM	10/14	CB
Caspian Tern *Hydroprogne caspia*	LM	13/14	CB
Common Tern *Sterna hirundo*	LM	10/14	CB
Little Tern *Sterna albifrons*	BV/LM	10/14	CB
Large Crested Tern *Sterna bergii*	LM	13/14	CB
Lesser Crested Tern *Sterna bengalensis*	LM	13/14	CB
Noddy Tern *Anous stolidus*	LM	13/14	CB
Columbidae			
Greyfronted Green Pigeon *Treron pompadora**	LM/AM	2/6	LF/HF
Orangebreasted Green Pigeon *Treron bicincta**	LM/AM	1/4	LF/HF
Green Pigeon *Treron phoenicoptera**	LM/AM	2/12	LF/HF
Imperial Pigeon *Ducula badia**	LM	1/2	HF
Blue Rock Pigeon *Columba livia**	R	8/11	LF/HF/CB
Nilgiri Wood Pigeon *Columba elphinstonii**	R	1/4	HF
Rufous Turtle Dove *Streptopelia orientalis*	LM	2/6	LF
Spotted Dove *Streptopelia chinensis**	R	3/11	LF/HF/CB
Emerald Dove *Chalcophaps indica**	R/AM	2/3	LF/HF
Psittacidae			
Alexandrine Parakeet *Psittacula eupatria*	R	2/3	LF
Roseringed Parakeet *Psittacula krameri**	R	2/3/6	LF/HF/CB
Blossomheaded Parakeet *Psittacula cyanocephala**	R/AM	2/3/6	LF/HF
Bluewinged Parakeet *Psittacula columboides**	R/AM	2/3/6	LF/HF
Lorikeet *Loriculus vernalis**	R/AM	2/3/6	LF/HF

Species	Status	Niche	Habitat
Cuculidae			
Pied Crested Cuckoo *Clamator jacobinus*	LM	3/6	LF/CB
Hawk Cuckoo *Cuculus varius**	LM	3/6	LF/HF
Indian Cuckoo *Cuculus micropterus*	LM	3/6	LF/CB
Small Cuckoo *Cuculus poliocephalus*	LM	3/6	LF/CB
Baybanded Cuckoo *Cuculus sonneratii*	LM	3/6	LF/CB
Plaintive Cuckoo *Cacomantis passerinus*	LM	3/6	LF
Drongo Cuckoo *Surniculus lugubris*	LM	3/6	LF
Koel *Eudynamys scolopacea**	LM	3/6	LF/HF/CB
Small Greenbilled Malkoha *Rhopodytes viridirostris*	R	3/6	LF/CB
Sirkeer Cuckoo *Taccocoua leschenaultii*	LM	3/6	CB
Centropidae			
Crow-pheasant *Centropus sinensis**	R	3/6	LF/HF/CB
Lesser Coucal *Centropus toulu*	R	3/6	LF
Strigidae			
Barn Owl *Tyto alba*	R	8/12	LF/CB
Great Horned Owl Bu*bo bubo*	R	2/6	LF/CB
Dusky Horned Owl *Bubo coromandus*	R	2/6	LF/CB
Brown Fish Owl *Bubo zeylonensis*	R	10/2/6	LF/CB
Collared Scops Owl *Otus bakkamoena**	R	2/3	LF/HF
Jungle Owlet *Glaucidium radiatum*	R	2/3	LF

Species	Status	Niche	Habitat
Brown Hawk Owl *Ninox scutulata*	R	2/6	LF
Spotted Owlet *Athene brama*	R	8/11	LF/CB
Mottled Wood Owl *Strix ocellata**	R	2/6	LF/HF/CB
Brown Wood Owl *Strix leptogrammica**	R	2/6	LF/HF/CB
Caprimulgidae			
Ceylon Frogmouth *Batrachostomus moniliger**	R	2/6	LF/HF
Indian Jungle Nightjar *Caprimulgus indicus**	R	2/3	LF/HF
Franklin's Nightjar *Caprimulgus affinis**	LM	2/3	LF/HF
Apodidae			
Edible-nest Swiftlet *Collocalia unicolor**	R	2	LF/HF
Whiterumped Spinetail *Chaetura sylvatica**	R	2/3	LF/HF
House Swift *Apus affinis** R	2/3	LF/HF	
Palm Swift *Cypsiurus parvus**	R	3/6	LF/HF/CB
Crested Tree Swift *Hemiprocne longipennis**	R	2/3	LF/HF
Trogonidae			
Malabar Trogon *Harpactes fasciatus**	R	1/2	LF/HF
Alcedinidae			
Lesser Pied Kingfisher *Ceryle rudis**	R	10/11	LF/HF/CB
Common Kingfisher *Alcedo atthis**	R	10/9	LF/HF/CB
Blue-eared Kingfisher *Alcedo meninting*	R	10/9	LF/CB
Threetoed Kingfisher *Ceyx erithacus*	LM	2/6	LF
Strokbilled Kingfisher *Pelargopsis capensis**	R	6/9	LF/HF/CB
Whitebreasted Kingfisher *Halcyon smyrnensis**	R	10	LF/HF/CB
Black-capped Kingfisher *Halcyon pileata*	R	10	CB

Species	Status	Niche	Habitat
Meropidae			
Chestnutheaded Bee-eater *Merops leschenaulti**	LM	3/11	LF/HF/CB
Bluetailed Bee-eater *Merops philippinus**	WM	3/5	LF/HF/CB
Green Bee-eater *Merops orientalis*	LM	3/5	LF/CB
Bluebearded Bee-eater *Nyctiornis athertoni**	R/AM	2	LF/HF
Coraciidae			
Indian Roller *Coracias benghalensis*	R/LM	2/11	LF/CB
Broadbilled Roller *Erystomus orientalis**	LM/O	2	HF
Upupidae			
Hoopoe *Upupa epops*	LM	6/8/11	CB
Bucerotidae			
Grey Hornbill *Tockus birostris*	LM	2	LF/CB
Malabar Grey Hornbill *Tockus griseus**	R	2	LF/HF
Malabar Pied Hornbill *Anthracoceros coronatus**	R	2	LF/HF
Great Hornbill *Buceros bicornis**	R	1/2	LF/HF
Capitonidae			
Green Barbet *Megalaima zeylanica*	R	2/6	LF
Small Green Barbet *Megalaima viridis**	R	2/6	HF
Bluethroated Barbet *Megalaima asiatica**	R	2/6	HF
Crimsonthroated Barbet *Megalaima rubricapilla**	R	2/6	LF/HF
Coppersmith *Megalaima haemacephala*	R	3/6	LF
Picidae			
Speckled Piculet *Picuminus innominatus**	R	2	HF
Rufous Woodpecker *Micropternus brachyurus**	R	2	LF/HF/CB

Species	Status	Niche	Habitat
Lesser Goldenbacked Woodpecker *Dinopium benghalense**	R	2	LF/HF/CB
Threetoed Woodpecker *Dinopium javanense**	R	2	LF/HF
Great Black Woodpecker *Dryocopus javensis**	R	1/2	HF
Yellowfronted Pied Woodpecker *Picoides mahrattensis**	R	2/6	LF/HF
Heartspotted Woodpecker *Hemicircus canente**	R/AM	2/3	LF/HF
Blackbacked Woodpecker *Chrysocolaptes festivus*	R	2	LF
Large Goldenbacked Woodpecker *Chrysocolaptes lucidus**	R/AM	1/2	LF/HF
Pittidae			
Indian Pitta *Pitta brachyura*	LM	3/6	LF/CB
Bush Lark *Mirafra assamica*	R/LM	3/5	LF/CB
Redwinged Bush Lark *Mirafra erythroptera*	R/LM	3/5	LF/CB
Malabar Crested Lark *Galerida malabarica*	LM	3/5/11	CB
Eastern Sky Lark *Alauda gulgula*	LM	3/5/11	CB
Hirundinidae			
Dusky Crag Martin *hirundo concolor*	LM	2/3/8	CB
Swallow *Hirundo rustica**	WM	2/3/8	LF/HF/CB
Wiretailed Swallow *Hirundo smithii**	WM	2/3/8	LF/HF/CB
Redrumped Swallow *Hirundo daurica*	LM	2/3/8	LF/CB
House Martin *Delichon urbica*	R	2/3/8	CB

Species	Status	Niche	Habitat
Laniidae			
Grey Shrike *Lanius excubitor*	LM	3/8/11	LF/CB
Rufousbacked Shrike *Lanius schach**	LM/AM	2/3	LF/HF
Brown Shrike *Lanius cristatus*	LM	3/11	LF
Oriolidae			
Golden Oriole *Oriolus oriolus**	LM	2/3	LF/HF/CB
Blackheaded Oriole *Oriolus xanthornus**	LM/AM	2/3	LF/HF/CB
Blacknaped Oriole *Oriolus chinensis*	WM	2/3	LF/CB
Dicruridae			
Black Drongo *Dicrurus adsimilis*	R	3/11	LF
Grey Drongo *Dicrurus leucophaeus*	LM	2/3	LF
Whitebellied Drongo *Dicrurus caerulescens*	LM	2/3	LF
Bronzed Drongo *Dicrurus aeneus**	R/AM	2/3	LF/HF
Haircrested Drongo *Dicrurus hottentotus**	LM/AM	2/3	LF/HF
Racket-tailed drongo *Dicrurus paradiseus**	R	1/2/3	LF/HF
Artamidae			
Ashy Swallow-shrike *Artamus fuscus**	R/LM	3/11	LF/HF/CB
Sturnidae			
Greyheaded Mynah *Sturnus malabaricus**	LM	2/3	LF/HF/CB
Brahminy Mynah *Sturnus pagodarum**	LM	2/3	LF/HF
Common Mynah *Acridotheres tristis**	R	3/11	LF/HF/CB
Jungle Mynah *Acridotheres fuscus**	R	2/3	LF/HF/CB
Hill Mynah *Gracula religiosa**	R/AM	2/6	LF/HF

Species	Status	Niche	Habitat
Corvidae			
Indian tree Pie *Dendrocitta vagabunda*	R	2/6/12	LF/CB
Whitebellied Tree Pie *Dendrocitta leucogastra**	R	1/2	HF
House Crow *Corvus splendens*	R	8/11	LF/CB
Jungle Crow *Corvus macrorhynchos**	R	3//68	LF/HF/CB
Campephagidae			
Pied Flycatcher-shrike *Hemipus picatus**	R	1/4	LF/HF
Large wood Shrike *Tephrodornis gularis**	R/AM	2/3	LF/HF
Common Woodshrike *Tephrodornis pondicerianus*	R	2/3	LF
Large Cuckoo-shrike *Coracina novaehollandiae*	R	2/3	LF
Blackheded Cuckoo-shrike *Coracina melanoptera*	R	2/3	LF/CB
Scarlet Minivet *Pericrocotus flammeus**	R	2/3	LF/HF
Small Minivet *Pericrocotus cinnamomeus**	R	2/3	LF/HF
Irenidae			
Common Iora *Aegithina tiphia**	R	2/3	LF/HF/CB
Goldfronted chloropsis *Chloropsis aurifrons**	R/AM	2/3	LF/HF/CB
Goldmantled chloropsis *Chloropsis cochinchinensis**	R	2/6	LF/HF
Fairy Bluebird *Irena puella**	R	1/2	LF/HF
Pycnonotidae			
Greyheaded Bulbul *Pycnonotus priocephalus**	R	1/2	HF
Rubythroated Bulbul *Pycnonotus melanicterus**	R	2/3	LF/HF

Species	Status	Niche	Habitat
Redwhiskered Bulbul *Pycnonotus jocosus**	R	3/6	LF/HF/CB
Redvented bulbul *Pycnonotus cafer*	R	3/6	LF/CB
Whitebrowed Bulbul *Pycnonotus luteolus*	R	3/6	LF/CB
Yellowbrowed Bulbul *Hypsipetes indicus**	R	1/2	HF
Black Bulbul *H. madagascariensis**	R/AM	2/3	LF/HF/CB
Timliinae			
Spotteed Babbler *Pellorneum ruficeps**	R/AM	2/3	LF/HF
Slatyheaded Scimitar Babbler *Pomatorhinus horsfieldii**	R	2/3/6	LF/HF
Whitethroated Babbler *Dumetia hyperythra**	R	3/6	LF/HF
Blackheaded Babbler *Rhopocichla atriceps**	R	1/4	HF
Common Babbler *Turdoides caudatus*	R	2/3	LF/CB
Large Grey Babbler *Turdoides malcolmi*	R	2/3	LF/CB
Rufous Babbler *Turdoides subrufus**	R	2/3	LF/HF
Jungle Babbler *Turdoides straitus*	R	3/8	LF/CB
Whiteheaded Babbler *Turdoides affinis*	R	3/11	LF/CB
Wynaad Laughing Thrush *Garrulax delesserti**	R	1/2	HF
Jerdon's Laughing Trush *Garrulax jerdoni**	R	1/2	HF
Quaker Babbler *Alcippe poioicephala**	R	2/3	HF
Muscicapinae			
Brown Flycatcher *Muscicapa latirostris**	R/WM	2/3	LF/HF/CB
Redbreasted Flycatcher *Muscicapa parva**	WM	3/6	LF/HF/CB
Whitebellied Blue Flycatcher *Muscicapa pallipes**	R	2/4	HF

Species	Status	Niche	Habitat
Redwhiskered Bulbul *Pycnonotus jocosus**	R	3/6	LF/HF/CB
Tickeel's Blue flyctacher *Muscicapa tickellieae**	R	2/3	LF
Verditer Flycathcer *Muscicapa thalassina**	R	2/6	HF
Greyheaded Flycatcher *Culicicapa ceylonensis**	R	2/4/6	HF
Rhipidurinae			
Whitethroated Fantail Flycatcher *Rhipidura albicollis**	R	2/3	LF/HF
Monarchinae			
Paradise Flycatcher *Terpsiphone paradisi**	LM	2/3	LF/HF/CB
Blacknaped Flycatcher *Monarcha azurea**	R	2/3	LF/HF
Sylvinae			
Fantail Warbler *Cisticola exilis*	R	3/5/11	CB
Streaked Fantail Warbler *Cisticola juncidis*	R	3/5/11	CB
Franklin's Wren-warbler *Prinia hodgsonii**	R	3/5	LF/HF/CB
Plain Wren-warbler *Prinia subflava**	R	3/5	LF/HF/CB
Ashy Wren-warbler *Prinia socialis**	R	3/5	LF/HF/CB
Jungle Wren-warbler *Prinia sylvatica**	R	3	LF/HF/CB
Tailor Bird *Orhtotomus sutorius**	R	3/6	LF/HF/CB
Blyth's Reed Warbler *Acrocephalus dumetorum**	WM	3/6	LF/HF/CB
Paddyfield Warbler *Acrocpehalus agricola*	WM	3/6	LF/CB
Booted Warbler *Hippolais caligata*	WM	3/6	LF/CB
Lesser Whitehroat *Sylvia curruca*	WM	3/6	LF/CB
Greenish Leaf Warbler *Phylloscopus trochiloides**	WM	3/6	LF/HF/CB

Species	Status	Niche	Habitat
Turdinae			
Magpie Robin *Copsychus saularis**	R	3/6	LF/HF
Shama *Copsychus malabaricus**	R	2/3	LF/HF
Pied Bushchat *Saxicola caprata*	R	2/3	LF/CB
Indian Robin *Saxicoloides fulicata*	R	2/3	LF/CB
Blueheaded Rock Thrush *Monticola cinclorhynchus*	LM	2/3	LF/CB
Blue Rock Thrush *Monticola solitarius**	LM	2/3	LF/HF/CB
Whistling Thrush *Myiophonus horsfieldii**	R/AM	2/3	LF/HF
Orangeheaded Ground Thrush *Zoothera citrina**	R/LM	2/3	LF/HF/CB
Blackbird *Turdus merula **	R/LM	2/3	HF
Paridae			
Grey Tit *Parus major**	R	2/3	LF/HF
Yellowcheeked Tit *Parus xanthogenys**	R	2/3	HF
Sittidae			
Chestnutbellied Nuthatch *Sitta castanea**	R	2/3	LF/HF
Velvetfornted Nuthatch *Sitta frontalis**	R	1/4	HF
Motacillidae			
Indian Tree Pipit *Anthus hodgsoni*	R	2/3	LF/HF
Paddyfield Pipit *Anthus noveaseelandiae*	R/LM	2/3/11	LF/HF
Forest Wagtail *Motacilla indica**	WM	2/3	LF/HF
Yellow Wagtail *Motacilla flava**	WM	2/3	LF/HF

Species	Status	Niche	Habitat
Grey Wagtail *Motacilla cinerea**	WM	2/3	LF/HF
Large Pied Wagtail *Motacilla maderaspatensis**	R	2/3	LF/HF
Dicaidae			
Thickbilled Flowerpecker *Dicaeum agile**	R	2/3	HF
Tickell's Flowerpecker *Diceaum erythrorhynchos**	R	2/3	LF/HF
Nectariniidae			
Purplerumped Sunbird *Nectarinia zeylanica**	R	2/6	LF/HF/CB
Small Sunbird *Nectarinia minima**	R	2/6	LF/HF
Loten's Sunbird *Nectarinia lotenia**	R	2/6	LF/HF
Purple Sunbird *Nectarinia asiatica*	R	2/6	LF/CB
Little Spiderhunter *Arachnothera longirostris**	R	2/6	HF
Zosteropidae			
White-eye *Zosterops palpebrosa**	R	2/6	LF/HF
Passerinae			
House Sparrow *Passer domesticus**	R	8	LF/HF
Yellowthroated Sparrow *Petronia xanthocollis*	R	2/3	LF
Ploceinae			
Baya *Ploceus philippinus**	R/AM	3/11	LF/HF/CB
Estrildinae			
Whitethroated Munia *Lonchura malabarica**	R	3/11	LF/HF/CB
Whitebacked Munia *Lonchura striata**	R	3/11	LF/HF/CB
Rufousbellied Munia *Lonchura kelaarti**	R/AM	3/11	LF/HF
Spotted Munia *Lonchura punctulata**	R	3/11	LF/HF/CB
Blackheaded Munia *Lonchura malacca**	R	3/11	LF/HF/CB

A CHECKLIST OF THE MAMMALS OF THE WESTERN GHATS (between 16° - 12°N)
Prepared on the basis of existing literature . Bats not listed.

√ = Known to occur; C = Common; * = Recorded in Kudremukh National Park Environs

Species	Lowland Forests	Highland Forests	Status	Remarks
Bonnet macaque *Macaca radiata*	√ *	√ *	C	Secondary forest dweller
Lion-tailed Macaque *Macaca silenus*		√ *	200+	10 troops noted during current study in KNP
Common Langur *Presbytes entellus*	√ *		C	Primary forests
Nilgiri Langur *Trachypithecus johnii*			C	Dense primary forests. Extension of range to KNP recorded in this study
Slender Loris *Loris tardigradus*	√		?	
Tiger *Panthera tigris*	√	√	8-10 Estimated	Rarely seen. No recent report of cattle lifting
Leopard *Panthera pardus*	√*	√	75-100 Estimated	Encountered more in open forest tracts near villages.
Leopard cat *Felis bengalensis*	√	√	?	
Rustyspotted cat *Felis rubiginosa*	√*		?	
Fishing Cat *Felis viverrina*	√*		?	
Jungle Cat *Felis chaus*	√*		?	
Malabar Civet *Viverra civettina*	√	√	?	Recently recorded to occur in lowland forests of Mookambika and Someshwara W/L sanctuaries as well as lowland/highland forests of KNP. Endemic

Species	Lowland Forests	Highland Forests	Status	Remarks
Small Indian Civet *Viverricula indica*	√	√	?	
Common Palm Civet *Paradoxurus hermaphroditus*	√	√	C	
Brown Palm Civet *P. jerdoni*	√	√	?	Endemic
Ruddy Mongoose *Herpestes smithii*		√ *	C	
Stripenecked Mongoose *H. viticollis*		√	?	
Brown Mongoose *H. fuscus*		√	?	
Striped Hyena *Hyaena hyaena*	√ *		?	Only in lowland scrub forests
Jackal *Canis aureus*	√ *	√ *	C	
Indian Fox *Vulpes bengalensis*	√ *		C	
Wild Dog *Cuon alpinus*		√ *	C	
Sloth Bear *Melursus ursinus*	√	√	?	
Common Otter *Lutra lutra*		√ *	?	Small population in Lakya dam backwaters
Smooth Indian Otter *Lutra perpsicillata*	√		?	
Clawless Otter *Aonyx cinerea*		√	?	
Giant Squirrel *Ratufa indica*	√ *	√ *	C	

Species	Lowland Forests	Highland Forests	Status	Remarks
Three-striped Squirrel *Funambulus palmarum*	√ *	√ *	C	
Dusky Striped Squirrel *F. sublineatus*		√	?	
Porcupine *Hystrix indica*	√*	√	C	
Blacknaped Hare *Lepus nigricollis*	√*	√	C	
Elephant *Elephas maximus*	?	?	?	Occasional individuals have been seen in the Lowland/ highland forests of the periphery of KNP.
Gaur *Bos gaurus*	√ *	√ *	C	
Sambar *Cervus unicolor*	√ *	√ *	C	
Spotted Deer *Axis axis*	√ *		C	
Barking Deer *Muntiacus muntjak*	√ *	√ *	C	
Mouse Deer *Tragulus memimna*	√ *	√ *	C	
Wild Boar *Sus scrofa*	√ *	√ *	C	
Pangolin *Manis crassicaudata*	√ *		C	

A CHECKLIST OF THE REPTILES OF THE WESTERN GHATS (between 16° - 12°N) Prepared on the basis of existing literature . Most of these occur in Kudremukh N.P.

CR = Critically endangered; VU = Vulnerable; LR-nt = Low risk- near threatened
LR-lc = Low risk-least concern; DD = Data deficient; NE = Not evaluated

ENDEMICS

TESTUDINIDAE - Tortoises/Terrapins

Indotestudo forsteni - VU

AGAMIDAE - Agamid lizards

Calotes rouxi - LR-nt

Draco dussumieri - CR

GECKONIDAE - Geckos

Cnemaspis indica - VU

Cnemaspis mysoriensis - DD

Hemidactylus m. maculatus - LR-lc

NON-ENDEMICS

CROCODYLIDAE - Crocodiles

Crocodylus palustris = VU

TESTUDINIDAE

Geochelone elegans - VU

TRIONYCHIDAE - Flapshell Turtles

Lissemys punctata punctata - LR-nt

GECKONIDAE

Cnemaspis kandianus - LR-lc

Hemidactylus brooki - LR-lc

Hemidactylus frenatus - LR-lc

Hemidactylus leschenaultii - LR-lc

TYPHLOPIDAE - Blind Snakes

Ramphotyphlops braminus - LR-nt

AGAMIDAE

Calotes calotes - LR-nt

Calotes versicolor - LR - lc

CHAMAELEONIDAE - Chameleons

Chamaeleo zeylanicus - VU

SCINCIDAE - Skinks

Mabuya carinata carinata - LR - nt

Mabuya maculatus - LR - lc

LACERTIDAE -

Ophisops jerdoni - DD

VARANIDAE - Monitor lizard

Varanus bengalensis - VU

NON-ENDEMICS - ..... Contd..

BOIDAE - Boas/Constricters-

Eryx conicus conicus - VU

Eryx johnii johnii - LR - nt

Python molurus molurus - LR-nt

COLUBRIDAE - Non-poisonous Snakes

Ahaetulla nasutus - LR-lc

Boiga forsteni - LR-nt

Chrysopelia ornata ornata - LR-nt

Dendrelaphis tristis - LR-lc

Elaphe helena helena - LR-nt

Lycodon aulicus - LR-lc

Macropisthodon plumbicolor plumbicolor - LR-nt

Ptyas mucosus mucosus - LR-nt

Xenochropis piscator piscator - LR-lc

ELAPIDAE - Poisonous snakes

Bungarus caeruleus - LR-nt

Calliophis macclellandi macclellandi - NE

Naja naja - LR-nt

Ophiophagus hannah - LR-nt

VIPERIDAE - Poisonous snakes

Echis carinatus carinatus - LR-nt

Vipera russelii russelii - LR-nt

PROFILE OF TWO TYPICAL SMALL SHOLAS OF KUDREMUKH N.P.
(Visual enumeration)

1. Shola around Kachige hole' (APRIL - MAY)

Calophyllum apetalum, *Hopea parviflora*, *Gordonia obtusa*

Syzygium cumini, *Mesua ferrea* are the dominant Species in descending order

Species	Family	Phenology	Status
Syzygium caryophyllatum (L) Aston	*Myrtacea*		Rare
Syzygium cumini (L) Skeels	*Myrtaceae*	Veg.	Scattered
Olea dioica Roxb.	*Oleaceae*	Veg. & Fr.	Common
Symplocos cochinchinensis (Lour.) Moore	*Symplocaceae*	Fr. & Veg.	Common
Elaeocarpus tuberculatus Roxb.	*Elaeocarpaceae*	Fr.	Common
Glochidion ellipticum wt.	*Euphorbiaceae*	Fr.	Common
Gordonia obtusa Wall ex W. & A.	*Theaceae*	Fr.	Fairly Common
Pterocarpus marsupium Roxb.	*Papilionaceae*	Veg.	Common
Daulbergia latifolia Roxb.	*Papilionaceae*	Veg.	Scattered
Albizia odoratissima (L.f.) Bantti	*Mimosaceae*	Veg.	Scattered
Mallotus philippensis (lam) Muell.	*Euphorbiaceae*	Veg.	Scattered
Carallia brachiata (Lour.) Meu	*Rhizophoraceae*	Veg.	Common
Sterculia guttata Roxb ex DC	*Sterculiaceae*	Fr.	Rare
Memecylon malabaricum (el.) Cogn.	*Melastomataceae*	Veg.	Scattered
Apodytes dimediata E. Mey. ex Arn.	*Ieacinaceae*	Fl.	Common
Canthium dioccum (Gaertn.) T & B.	*Rubiaceae*	Fl.	Scattered
Diospyros pruriens Dalz	*Ebenaceae*	Fr.	Scattered
Hopea parviflora Bedd.	*Dipterocarpaceae*	Veg.	Fairly Common
Garcinia cambogia (Gaertu) Desr.	*Elusiaceae*	Veg.	Rare
Garcinia indica (Dup-Thou) Choisy	*Elusiaceae*	Fr.	Common
Myristica dactyloides Gaertn.	*Myristicaceae*	Veg.	Common

Species	Family	Phenology	Status
Mesua ferrea L.	*Clusiaceae*	Veg.	Common
Laphopetalum wightianum Arn.	*Celastiaceae*	Veg.	Rare
Mangifera indica L.	*Anacardiacea*	Veg.	Scattered
Persea macrantha (nees) Kostera	*Lauraceae*	Veg.	Common
Cinnamomum sp.	*Lauraceae*	Veg.	Common
Caryota urens L.	*Arecaceae*	Fl.	Scattered
Trees of lower strata, undergrowths, Taxa at the periphery of Sholas and climbers.			
Wenlaridia thyrroidea (R & S.) Steud.	*Rubiaceae*	Veg.	Common
Premna coriacea cl.	*Verbenaceae*	Fl.	Scattered
Rourea minor (Gaertn.) Alst.	*Connaraceae*	Veg.	Scattered
Ficus arnottiana Miq.	*Moraceae*	Veg.	Rare
Canthium dicoccum (Dup. Thou.) Choisy	*Rubiaceae*	Veg./Fl.	Scattered
Flacourtia monana Grah.	*Flacourtiaceae*	Veg.	Scattered
Dichopetalum geloniaoides (Roxb.) Engler	*Dichopetalaceae*	Veg.	Scat.
Nothopegia racemosa (Dalz.) Ramam.	*Anacardiaceae*	Veg.	Rare
Eurya japonica Thunb.	*Theaceae*	Veg.	Common
Euonymus indicus wall.	*Celastraceae*	Veg.	Common
Salixt etrasperma Roxb.	*Salicaceae*	Fr.	Common
Homonoia riparia Lour.	*Euphorbiaceae*	Fr.	Common
Poiceloneuron indicum Bedd.	*Clusiaceae*	Veg.	Very rare
Flacourtia indica (Burm.) Merr.	*Flacourtiacea*	Veg.	Rare
Allophylus cobbe (L.) Raeusch.	*Sapindaceae*	Fl.	Common
Bridelia crenulata Roxb.	*Euphorbiaceae*	Veg.	Common
Lagerstroemia parviflora Roxb.	*Lythraceae*	Veg.	Rare
Breynia retusa (Demst.) Alston	*Euphorbiacea*	Veg.	
Toona ciliata Roemer	*Meliaceae*	Veg.	Scattered
Holigarna arnothiana Hk.f.	*Anacardiaceae*	Veg.	Rare

Species	Family	Phenology	Status
Gomphandra tetrandra Wall. ex. Lindl.	*Leaeinaceae*	Fl.	Scattered
Gnetum sp.	*Gnetaceae*	Veg.	Common
Bassia latifolia Roxb.	*Sapotaceae*	Veg.	Common
Litsea floribunda (Bl.) Gamble	*Lauraceae*	Veg.	Scattered
Schefflera sp.	*Arabiaceae*	Fl.	Common
Leea indica (beam. f.) Merr.	*Leeaceae*	Fl.	Common
Careya arborea Roxb.	*Lecythidaceae*	Fr.	Common
Archidendron monadelphum (Roxb.) Niels	*Mimosaceae*	Veg./Fr.	Common
Bischofia javanica Bl.	*Euphorbiaceae*	Veg.	Scattered
Ziziphus rugosa Lam.	*Rhamnaceae*	Veg.	Common
Phoenix humilis Royle	*Arecaceae*	Fr.	Common
Calamus sp.	*Arecaceae*	Veg.	Common
Maesa indica (Roxb.) DC.	*Myrsinacae*	Veg.	Common
Goniothalamus sp.	*Anonaceae*	Veg.	Scattered
Tarenna sp.	*Rubiaceae*	Fl.	Few
Microtropis sp.	*Celastraceae*	Fr.	Rare
Ligustrum sp.	*Oleaceae*	Veg.	Scattered
Mussaenda laxa (J. Hookera)	*Rubiacea*	Fl.	Common

2. SHOLA PATCH BEYOND KARMANNU HALLA (APRIL - MAY)

Species	Family	Phenology	Status
Homonota riparia Lour.	*Euphorbiaceae*	Fl.	Common
Pongamia pinnata (L.) Pierri	*Papilionaceae*	Veg.	Scattered
Mallotus philippensis (Lam.) Muelf.	*Euphorbiaceae*	Veg.	Scattered
Anthocephalus sp.	*Rubiaceae*	Veg.	Rare

Species	Family	Phenology	Status
Mussaenda laxa (J. Hooker) Hutch ex Gamble	*Rubiaceae*	Fl.	Fairly common
Wendlandia thryrsoidea (R & S.) Steudel	*Rubiaceae*	Fl.	Common
Olea dioica Roxb.	*Oleaceae*	Fruits	Common Tree
Artocarpus heterophyllus Lam.	*Moraceae*	Fruit's	Scattered
Lagerstroemia parviflora Roxb.	*Lythraceae*	Veg.	Scattered
Dimocarpus longan Lour.	*Sapindaceae*	Fl.	Common
Careya arborea Roxb.	*Leeythidaceae*	Veg.	Common
Bassia latifolia Roxb.	*Sapotaceae*	Fl.	Scattered
Garcinia cambogia (Gaertn.) Desr.	*Clusiaceae*	Fl.	Scattered
Holigarna grahamii (Wt.) Kurr.	*Anacardiaceae*	Veg.	Scattered
Mangifera indica L.	*Anacardiaceae*	Veg.	Scattered
Actinodaphne sp.	*Lauraceae*	Veg.	Scattered
Actinodaphene semicarpifolia Nees.	*Lauraceae*	Seedlings	Rare
Litsea floribunda (Bl.) Gamble	*Lauraceae*	Veg.	Scattered
Cinnamomum sp.	*Lauraceae*	Veg.	Scattered
Canarium strictum Roxb.	*Burseraceae*	Seedlings	Rare
Elaeocarpus serratus L.	*Elaeocarpaceae*	Veg.	Rare
Artocarpus hirsutus Lam.	*Moraceae*	Veg.	Scattered
Dalbergia latifolia Roxb.	*Papilionaceae*	Veg.	Scattered
Persea macrantha (Nees) Kosterm.	*Lauraceae*	Veg.	Fairly common
(There are good no. of seedlings and offshoots from cut part of stems)			
Butea frondosa Roxb.	*Papilionaceae*	Veg.	Scattered
Bischofia javanica Bl.	*Euphorbiaceae*	Veg.	Common
Poeciloneuron indicum Bedd.	*Clusiaceae*	Seedlins	Occur rarely
Caryota urens L.	*Anacardiaceae*	Veg.	Common

THE UPPER PART OF THE SHOLA IS OCCUPIED BY THE FOLLOWING TREES

Species	Family	Phenology	Status
Bridelia crenulata Roxb.	*Euphorbiacea*	Fl.	Scattered
Buchanania lanzan spreng.	*Anacardiaceae*	Veg.	Common
Grewia tiliaefolia Vahl.	*Tiliaceae*	Veg.	Scattered
Dillenia pentagyna Roxb.	*Dilleniaceae*	Veg.	Scattered
Emblica officinalis Gaertn.	*Euphorbiaceae*	Veg.	Scattered
(Moderate sized gooseberry trees found distributed in this Shola)			
Flacourtia montana Grah.	*Flacourtiaceae*	Veg.	Rare
UNDERGROWTH AND CLIMBERS ENUMERATED IN THIS PATCH			
Rubus fockei Gandhi	*Rosaceae*	Veg.	Scattered
Urena lobata L.	*Malvaceae*	Fl.	Scattered
Callicarpa tomentosa (L.)	*Murr. Verbenaceae*	Fl.	Common
Clerodendrum viscosum Vent.	*Veibenaceae*	Fl.	Common
Leea indica (Burm) Merr.	*Leeaceae*	Fl.	Common
Allophylus cobbe (L.) Raeu.	*Sapindaceae*	Veg.	Scattered
Toddalia asiatica (L.) Lam.	*Rutaceae*	Veg.	Common
Jasminum malabaricum Wt.	*Oleaceae*	Fl.	Common
Artabotrys zeylanicus Hk. & Th.	*Anonaceae*	Veg.	Scattered
Acacia pennata L.	*Mimosacea*	Fl.	Common
Maesa indica (Roxb.) De.	*Myrsinaceae*	Veg.	Common
Dichapetalum gelonioides (Roxb.) Engler	*Dichapetalaceae*	Fl.	Scattered
Strychnos dalzelli cl.	*Longaniaceae*	Veg.	Scattered
Pothos scandens L.	*Araceae*	Veg.	Common
Celastrus paniculatus Willd.	*Celastraceae*	Veg.	Scattered
Smilax zeylanica L.	*Liliaceae*	Fl.	Common

Species	Family	Phenology	Status
Elaeagnus conferta Roxb.	*Elaeagnaceae*	Veg.	Rare
Nilgirianthus heyneanus (Nees) Bremek	*Acanthaceae*	Veg.	Common
Calamus sp.	*Arecaceae*	Veg.	Scattered
Rubia cordifolia L.	*Rubiaceae*	Fl.	Abundant
Ixora nigrescens W & A.	*Rubiaceae*	Fl.	Scattered
Psychotria dalzelli, Hk.	*Rubiaceae*	Fl.	Scattered
Xeromphis spiosa (Thunb.) Keay.	*Rubiaceae*	Veg.	Scattered
Pinanga dicksonii (Roxb) Schif.	*Arecaceae*	Veg.	Common
Ardisia solanaceae Roxb.	*Myrsinaceae*	Fl.	Rare
Lasianthus acuminatus Wt.	*Rubiaceae*	Fl.	Scattered
Among grasses the following are found:			
Leucas marrubioides Dest.	*Labiaceae*		
Phlebophyllum canaricum (Bedd.) Bremek.	*Acanthaceae*		
Atylosia lineata W & A.	*Papilionaceae*		
Wendlandia thrysoidea (R & S) Steudel	*Rubiaceae*		
Orchid flora of the Shola patch includes the species *Vanda, Bulbophyllum, Cymbidium* etc.			

Significance And Role Of Universities In Biodiversity Research

Dr. B. Abdul Rahiman
Chairman, Dept. of Life Science,
Kuvempu University, Jnana Sahyadri - 577 451, India.

Abstract

Sustainable livelihood and food security of the entire world population is inseperably linked to the availability of biodiversity. Unfortunately the biodiversity of the world, especially that of the tropical region is dwindling at an unprecedented rate. Therefore, in the later half of the present century the biodiversity research flagged off with a bang. Probably it will remain in the forefront of all biological research throughout the first half of the next century. Unlike the other research fields, biodiversity research uses the 'nature' as laboratory, although well set labs with sophisticated equipment would realize a better outcome. Among the institutions involving in full time research or research cum other activities, universities stand a class apart because of the autonomy they enjoy, that is, they can plan, select, diversify and change the field at their own level. Because of this, the universities in India can play a crucial role in biodiversity research. A field in which the Universities could play a major role is that of medicinal plants. Because of the network of man power- teachers, students and the availability of young, talented and enthusiastic researchers as Ph. D. scholars and the contact they can make with the society through the parents and guardians of pupils, the universities have the potential to pool together the available local and tribal knowledge and expertise in traditional medicine. They can make use of the Western Ghats and other regions to survey, collect and identify the medicinal plants. Many universities have already made substainatial contributions, especially in listing the flora and fauna and studying the different parameters which are crucial in maintaining the biodiversity.

Biodiversity

Biodiversity is the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part, this includes diversity within the species, between species and the ecosystem (Anonymous 1992).

According to World Conservation Monitoring Centre (WCMC), the total number of species described at the global level so far is 160,000. However, the Centre estimates that there are likely to be 17,980,000 species (Khoshoo, 1995). However, some scientistis put the total figure of global species at 30,000,000.

The human civilization depends directly or indirectly on this biodiversity for their basic needs, viz., food, fodder, fuel, fibre, timber, rubber, leather, medicine etc. Ironically man depends only upon a narrow spectum of organisms as resources. For example, our basic food-cereal, comes from just three crop species. - wheat, rice, and maize. However, there are numerous varieties of each one of the major crops. For instance 45,000 accessions of rice are presently being maintained in repositories of germplasm at Rice Research Institute, Cuttack, Orissa, India. Unfortunately, the modern human society has retained only a few of high yeilding varieties of crops for the regular cultivation practices.

What if these selected varieties of crops are devastated by some calamities - man made or natural ?. If the biodiversity is saved, probably we may able to use the alternate crops or varieties to overcome the calamaities. Therefore, we may safely conclude that sustainable livelihood and food security of the entire world population is inseparably linked to the availability of biodiversity.

Biological extinction is a fact of life. As new species evolve, the old ones give way to the others. In the past, however, the pace of extinction was very slow - probably one species every 1000 years (Sinha, 1997). Man is not only a great inventor and builder, but he has also proved to be the most destructive force ever to appear on the face of earth. He has mercilessly sacrificed the forests to fulfil some of his immediate needs and led to the destruction of ecosystem. This has speeded up the pace of extinction and according to a conservative estimate by World Conservation Union (IUCN), 3 species become extinct every day (Sinha, 1997).

The seriousness of the dwindling of biodiversity was felt by the scientists around the world and research activities towards the understanding of the status of biodiversity flagged off during the later half of the present century. Since the issue involved is very important to the sustainable utilization of bioresources and both developed and developing nations are interested in this, the biodiversity research will probably remain in forefront of all the biological research, at least till the end of the first half of the next century.

Compared to the common research activities in the modern days, the scope and magnitude of biodiversity research is quite different and entirely new approach is to be followed

to tackle this. Research laboratories with sophisticated equipment and highly specialized/ trained experts are not required for biodiversity research, though such set up would definitely realise better result. Here the researchers have to use the 'nature' as laboratory and therefore a totally dedicated network of man power with real concern for the biodiversity is an essential prerequisite for this type of research. Because of these special nature, the universities in India can play a crucial role in biodiversity research.

Scope of Universities

Among the research institutions involving in full time research or research cum extention activities, university system stands a class apart.

Universities are institutions of higher learning engaged in both teaching and research. Universities with their post graduate centres/complexes and undergraduate colleges are functioning under the guidance and direction of University Grants Commission (UGC) which was established in 1956, by an Act of the Parliament. The UGC caters to wide ranging needs of students at the plus -3 level and beyond. According to the latest UGC statistics, there are 151 State , 13 Central , 36 Deemed universities and 14 Institutions of national importance as well as 8620 colleges affiliated to various Universities. More than 300,00 teaching staff conduct academic programmes for over 5 million students. The enrolment goes up at the rate of 4.5% each year. Unfortunately, UGC has no fund of its own. It receives grants from the Central Government through the Ministry of Human Resource Development.

The geographical spread of UGC institutions is such that on an average a high school graduate has access to an institution of higher learning within the radius of 100 Km in the rural areas and very much less in the semi-urban areas (NAAC, 1996). The advantages of university research are many, though they have their own drawbacks like resource crunch and financial problems.

The advantages

1. Unlike research institutions which have been established for some specific research requisites and therefore have to follow the rigid, earmarked research outlays, the universities can plan, select, execute, diversify and change the field of research or topics at its own level and many a times at the level of research guide/project head of principal investigator level. Here the teachers have a free hand in selecting the topic of their choice.

2. There is not must disturbance in the form of administrative duty/transfer/extention activities/public responsibilities, at least in the lower and middle strata of teaching.

3. The main duty, namely teaching and regular guidance to research students will provide a feed back of latest information and at the same time keep them, in touch with the basic information.

4. Probably an advantage which no other Research Institute can have at the national level, is the availability of vast network of man power in the form of teaching faculty in the undergraduate level and both teaching and research staff in the graduate level.

5. Another equally important advantage is the placement of the many of the colleges in the rural areas which are well connected to biologically rich areas.

6. Of greatest importance is of the availability of young, talented and enthusiastic researchers, who are prepared to work for very little remuneration because of the incentive of higher degrees like M. Phil. and Ph. D.

7. University researchers can have better interactions with the locals and public because of the interaction of students, parents and guardians. No research worth the name can be carried out in biodiversity field without the cooperation and help of locals.

8. Finally, because the teachers are part and parcel of the local society, the retrieval of information, especially of the delicate and confidential ones (eg. identity of medicinal plants which are used for a particular cure) from the public is easier to the university researchers.

Now let us look into a specific instances of the role universities in biodiversity research.

When Prof. Madav Gadgil of Centre for Ecological Studies, was asked by the Karnataka Government to assess the Western Ghats development project, he carried it out with the help of colleges located in the hill areas. Teachers and students of 28 colleges conducted field observations on components of development programmes and conducted extensive interviews with local people as to their reception and aspirations. Prof. Gadgil says that the report based on this feedback was welcomed by the Govt. of Karnataka and many of their suggestions were implemented (Gadgil, 1992).

A field in which the Universities could play a major role is that of medicinal plants. India had a glorious past as far as the herbal medicine is concerned. Reference to the curative properties of some herbs can be traced back to the time of 'Rig Veda' which is estimated to be of the period 3,500-1,800 BC. Two important works on Indian system of medicine were those of Charaka (Charakasamhita) and Susruta (Susruthsamhita). Unfortunately a large amount of unreliable information had crept into our medicinal plant literature.

Apart from the written complete or incomplete records about the ancient medicinal herbs, some knowledge on the subject has also descended through generation, and has survived through times among the present day societies through oral folklore, especially among aboriginal tribes living in remote forest areas.

Before synthetic chemicals dominated medicine, as they do today, roughly 80% of all drugs were derived from plant materials. Medicinal plants are as potent and effective today as they were thousands of years ago and are still today a big business. Roughly 25% of the medicinal prescriptions come from higher plants, totaling about $ 6 billion in annual sale. Two thousand different plants are used medicinally in India (Jain S. K., 1983, Koopowitz and Kaye, 1990 & FRLHT, 1995).

The Western Ghats are considered to be treasure house of medicinal plants. Not much informations is available on the medicinal plants of this tract. With the large scale destruction of the wild environments, especially that of the tropical region, sources for herbal remedies are getting scarce.

More than 22 Universities are located comparatively close to the Western Ghats stretch from south Gujarat to Kanykumari. These Institutions of higher learning with their battery of teachers, scholars and students could play a vital role in pooling together the available knowledge and expertise in traditional medication. They can also collect information about the availablility of medicinal plants in the Western Ghats and other regions and enrich our knowledge regarding the tremendous potential stored within many species. Many universities have already made substantial contributions, especially in listing out the flora and fauna and studying the different parameters which are crucial in maintaining the biodiversity.

Conclusion

University teachers apparently have more autonomy in their work than do those in many other professions. More than 151 state universities, 13 Central Universities, 36 Deemed universities and 14 Institutions of National importance, with 8,620 colleges and more than three hundred thousand teachers and 5 million and odd students, are well distributed throughout the country. Biodiversity research uses 'nature' as laboratory and therefore these Institutions of higher education could play a major role in the study of bioresources and conservation of biodiversity. A field in which the universities could play a major role is gathering the knowledge and expertise in traditional mediationas and availability of medical plants in the forest ecosystem.

References

Anonymous, 1992. The Convention of Biological Diversity, Rio de Janeiro, Brazil.

Gadgil, M. 1993. Conserving the Biodiversity of the Western Ghats :

A participatory approach. Centre for Ecological Sciences, Bangalore.

FRLHT, 1995. An User's Guide to Medicinal Plants. Foundation for Revitalisation of Local Health Traditions, Bangalore.

Jain, S. K. 1983. Medicinal plants, National Book Trust of India, New Delhi

Khoshoo, T. N. 1995. Census of India's Biodiversity: Task ahead.

Curr. Sci., 69 (1): 14-17.

Koopowitz, H. and Kaye, H. 1990. Plant extinction, a Global Crisis. Christopher Helm, London.

NAAC, 1996. Quality Education through Self study and External Education. National Assessment and Accreditation Council, Bangalore.

Sinha, R. K. 1997. Global Biodiversity. INA Shree publishers, Jaipur.

Biodiversity And The Media

Prof M. Sudhaker Rao
Retd. Principal, Poornaprajna College, Udupi

"Love and respect for living creatures must always be seen to flow from love and respect for the higher qualities and aspirations of mankind. All those who see the need for saving the world's wildlife, whether animal lovers, naturalists, scientists, sportsmen or simply people of goodwill and public spirit, must endeavor to work together amicably and to good purpose. United, we can and will save world's biodiversity. Divided, we could lose it forever."

- The World Wildlife Charter, 1962.

Man's life on earth is inexplicably bound with the nature around him. Though scientists may explain it away by several physical, chemical and mathmatical principles and models, the fact remains that such explanations often make the relationship rather highly technical and didactic. I have often felt that the relationship defies explanation. No doubt the relationship has undergone a sea change. The nature around man has been his friend, his tutor and even his enemy. Man has drawn heavily from animal and plant life materials for his food, clothes, housing and medicines. They have inspired him and given him joy. They have also been responsible for originating customs, thus influencing the entire mode of the human society.

The Pioneer

Biologists know a great deal about animals and plants that exist today and that existed in the distant past. Aristotle, who devoted 45 of the 62 years he lived to scholarly persuits, wrote nearly 300 works. Not all of them reached us, naturally, remembering that he lived from 384 to 322 BC, where there was no printing press and no media coverage. Nineteen of his 300 works dealt with animals, and 10 of them contained descriptions of 454 animals, where he attempted to describe the habits, attempted at a classification and even offered some generalisations and conclusions. What Aristotle did in his *The History of Animals* had laid the foundation for an in depth study of biodiversity. If Aristotle committed errors,

it was too natural, for his knowledge was insufficient as he had no access to literature, if it ever existed then. The remarkable thing about *The History of Animals* is that it contains a lot of information that is still correct and true.

The Gap in knowledge

Today over a million species of animals and plants inhabiting our planet have been described. Of these insects alone account for nearly a million. Aristotle described only 60 species of insects. Linnaeus (1707-1778), often called as the Father of taxonomy, knew 1,929 species of insects. If you consider the crustaceans, we know today more than 20,000 species. Aristotle knew only 15 and Linnaeus knew, 89. The same applies to other groups of life forms. If Aristotle described 454 animals, Linnaeus described 4,200. All this leads us towards one thing: over a period of 2000 years that divided Aristotle from Linnaeus, the list of animals grew only ninefold. In the last 200 years since Linnaeus, it has grown 300-fold. The reason for the explosion in knowledge of biodiversity can be attributed to an evolution of techniques, access to literature, and a phenomenal rise in coverage by media. If all this has created an impression in people's mind that there is not a single spot on Earth which has not been studied thoroughly and the list of animal and plant diversity as closed, they are in for a surprise of their lives. In fact Russia alone recorded nearly 20 species of small mammals in this century itself. Many more must be lurking in unknown impenetrable forests of South America, Africa, Australia, not to forget our own India. Was not the duck-billed platypus (*Ornithorhynhus anatinus*) discovered only in 1797? Was not the Okapi, a close relative of the giraffe discovered in this century itself? Did the Europeans see live apes till 1830, when the first Orangutan was brought to the London zoo? Did not a Dutch biologist discover a black-capped dwarf marmoset (a primate) in the lower *Bio Medina* of the south east Amazon just the other day? "We know of so many species to date" would be a cautious statement hinting that many more are to come to light in days to come.

Agreed that there are several million species of life forms. Of these how many are native of India? Would it be 5,00,000? Would it be 6,00,000? Nobody can say for certain. If the second figure is a rough estimate, then only about 1,25,000 have been described to date. Events of this meagre percentage of Indian species that have been scientifically described, a large proportion has been done by the British and Western scientists and the specimens are located in the museums of Natural History and Kiew Herbarium in London. Among the 82,000 preserved museum specimens of Indian animals, 30,000 are to be found only abroad. There are ten times more specimens of Indian birds abroad than in India itself !

The Lifescape Project

If a directory or database of Indian life-forms is not available, India would have to increasingly depend on foreign agencies for information on a single specimen of Indian origin. It is like knocking at the doors of the Rice Research Institute of Phillipines for a study of Indian rice material. Apart from specimens themselves, there is the handicap of poor handling of the available information **. Hence the need of the hour is to identify and record more than 4,00,000 species and maintain our status as one among the 12 megadiversity hotspots of the world. This is the objective of the Lifescape project, to be supervised by Prof. Madhav Gadgil of the Centre for Ecological Sciences at the Indian Institute of Science (IISC) in Bangalore.

This never-before attempted giant exercise is in honour of the birth centenary of Dr. Salim Ali, an Indian Ornithologist of repute. His several books on birds, either written alone or in association with Dillon Ripley "played a key role in stimulating popular interest in India's rich biodiversity". The project would help to create popular interest just as Salim Ali's works created interest in birds ever since they appeared in print. Lifescape's illustrated account of about 5000 species would help teachers and students alike not only in identifying these species but also to use them for a further in-depth study. The account would also generate popular interest.

A similar project called the Western Ghat Biodiversity Network (WGBN) involving fifteen colleges in and around the Ghat line is already giving excellent inputs in studying landscape ecology of the Western Ghats. This is going to be the basis of the larger lifescape model. The Lifescape Project is beautiful and enlivening in that there is no bar on participation in the project. The person participating in the compilation, apart from involving himself in this great task, gets credit for the work done. Naturalists, both professional and amature, students of biology and their teachers could come forward to contribute, and justify the inclusion of their teachers could come forward to contribute, and justify the inclusion of their choices in the list of 5000.

** *A representative and well maintained specimens of most of the species are housed in the museums of the Bombay Natural History Society (BNHS), the Zoological and Botanical Surveys of India(ZSI & BSI). For example, BNHS has over 35,000 bird, 10,000 mammal, over 10,000 reptile and a large number of insect specimens besides other invertebrate species. BNHS, ZSI and BSI have published information on not*

The Lifescape project, however, is not a technical documentation, for which technical skill is required and training is a must. It is to be done without technical inputs, and is meant for monitoring ongoing changes. For example are medicinal plants like *Rauwolfia serpentina* (sapagandha) and *Taxus baccata* declining in numbers? What is the extent of overexploitation? How many medicinal plants are in regular commercial use and what is their status now? Any local tribal or one who gathers and supplies these to commercial establishment probably will know the answer. Similarly local fishermen can identify more than a hundred species of fish and an amateur naturalist, an equal or more number of birds. Thus relevent information can be obtained from these sources and can be synthesized later. Such information collection could be a good exercise for biology students, at present bogged down by laboratory studies unaccompained by observation of life forms in their natural surroundings. For them it would be excellent exposure.

Significance

The Lifescape project is of great significance as the country's biodiversity is eroding rapidly. Large scale deforestation, overexploitation, encroachment both legal and illegal for habitation, altered land use, poaching, mining activities, establishment of megaprojects, all contribute to a sad decline in diverse bioforms and biowealth. Biowealth would also be the raw material for many industries in the years to come as biotechnology would occupy the forefront in world economy. As the prospect of losing biodiversity resources looms large, efforts must be put in towards sustainable management of resources. Eventually when the Lifescape Project is completed and published it will not only provide factual information but also would make its reading a pleasure for lovers of life forms, for, in the words of Gerald Durell, "we have inherited an incredibly beautiful and complex garden, but the trouble is that we have been appalingly bad gardeners. We have not bothered to acquaint ourselves with the simplest principles of gardening. By neglecting our garden, we are storing up for ourselves, in the not very distant future, a world catastrophe as bad as any atomic war. We now stand so aloof from nature that we think we are God. This had always been a dangerous supposition."

---

only the specimens but also on the natural history and distribution of these species. It is intersting to note that the Siberian Crane was illustrated by the Court artist Mansoor and described by Emperor Babur long before it was discovered and described by scientists (Ali. Salim,1927 Moghul Emperors as Naturalists. JBNHS 37(4) : 833-861 .....). - Eds.

The Media and Biodiversity

When Gregor Johann Mendel (1822-1884) the Austrian monk, published his observations of pea plants in the Journal of Natural History Society of Brunn, it hardly reached anybody outside Austria. So much so the credit for the rediscovery in 1900 of the basic principles of genetics discovered by him went to three people, and one of them, Von Tschermak, was from Austria itself! Mendel did his work when he was about 35 and it should be noted that his work did not receive the exposure it deserved. We can also guess, whatever newspapers were in existence then would have given a lukewarm response to the work.

What about us? In 1976, for a population of million, the total circulation of all our dailies was only 9.38 million according to a report of the Registrar of Newspapers Report for 1977-78. This was equal to the circulation of just one Japanese newspaper. The total newsprint consumed in India is less than what a number of daily newspapers consume in England and United States respectively! Needless to say the circulation would certainly depend on literacy for the two go hand in hand. For a state like Kerala, which has achieved almost 90% literacy, people must be exposed to a lot of issues.

For that matter it is also necessary to find out how much space is actually alloted in a newspaper or a popular magazine for socially relevent issues like health, family planning and education? About 25 years ago it was 6% of the total space, which rose to above 9.05% 5 years later. Did it indicate that the press, as a rule does not care very much for social issues and does it mean that it does not understand its own role in social development?

What is the position now? Mass media have found a new role. Many newspapers have special supplements on social issues, many others have supplements on science and technology. There are monthlies that are exclusively devoted to articles on science. Even regional language newspapers and glossies do not feel shy of carrying articles on environment, ecological degredation deforestation, pollution, poaching and the like. Many in doing so, become mouthpieces of environmentalists. Whether it is the establishment of a mega industry that is likely to harm the environment or illegal quarrying, wanton destruction of forests, people's movements against such relevent issues find a place in the press. Discussion of such issues appearing in the press can whip up passions too. The advent of the electronic media added a new dimension to the exposure. While always believing that visual is more appealing than auditory, television programmes on greening and animal stories have developed powerful appeal. Many channels are exclusively devoted to such issues and carry quite a high viewership. Are there other avenues of exposing to people at large to relevent issues such as an assault

on biodiversity and our rich heritage? With the Prasar Bharathi Bill becoming a reality what is an store for India's megadiversity? How best the media at our disposal can do in job?

1. Akashavani (All India Radio)

All India Radio's network now comprises 162 broadcasting centres consisting of 154 full fledged stations, 3 relay centres, two auxiliary centres and three exclusive 'Vividh Bharathi/ Commercial centres. It has 142 transmitters, 43 short wave transmitters and 74 FM transmitters. The present national radio coverage is 87% by area and 96% by population. It has established networking through INSAT-D for many of its relay programmes.

All India Radio has a News Service Division, Home Services, Sports Broadcasts, Family Welfare, Yuvavani Services, Farm and Home and Educational programmes. Farm and Home programme have plenty of scope for broadcasting biodiversity-oriented topics. At present Educational programmes are broadcast by 48 stations for schools and 29 stations relay them. The service is entirely regional, and each lasts 40 minutes day. Though the programme is mostly syllabus-oriented, some states are already giving importance to environmental-related programmes. There is also a broadcast of programmes for adults from 48 centres on science and technology.

The Farm and Home programme is broadcast by 92 AIR stations for 40-60 minutes a day on all days a week. Each broadcast contains one programme on environment.

2. Doordarshan

Doordarshan with its 31 programme production centres (PPC) and 553 transmitters of varying powers, had a major breakthrough with the commissioning of the satellite channels in 1993. Doordarshan reaches about 82% of the country's population and has, in addition to its popular channel DD1, an entertainment channel DD2, entertainment and target audience channel DD3, Regional language Channel DD4 (Kannada, Malayalam, Telugu, Tamil), DD5 (Assamese, Bengali, Oriya) and DD-6 (Punjabi, Gujarathi, Kashmiri).

Doordarshan's educational programme under the educational technology version (ETV) is of 45-60 minute duration and covers topics of varying interests and levels. The programmes are not syllabus oriented and the thrust is on moving away from the curriculum oriented approach and aim at reducing the classroom load.

The science programme 'Turning Point' is a science magazine telecast everyweek. It has vast scope and a vast viewership too because of its wide coverage of issues concerning

environment, new breakthrough in different branches of science and technology and application of technology day to day life. Projecting eco awareness and scientific tempo are also done by way of serial documentaries, telefilm, teleplays, spots, quiz, and short films. It can, if the producers mind, review the work of several organisations doing quiet work in restoration and challenges before them, whether it is saving birds from oil-spill or live animals from clandestine exports or creating awareness among the public about why saving the environment will be the next century's biggest challenge.

3. Films

The films Divisions, a part of Ministry of Information and Bradcasting, started about 45 years ago, has always aimed at motivating people at nation building. The Division caters to about 13,500 cinema theatres all over the country and to nontheatrical circuits too. For instance to Directorate of Information and Broadcasting, mobile units of State govts, Doordarshan, field units of family welfare, educational institutions and even to voluntary organisations. The scope here is unlimited. It can focus on many national problems, project image of the land and its rich heritage. Since it is a wing of the govt, it is doubtful whether it will stress or issues in which many politicians themselves are involved.

4. Press Information Bureau

It is "Man Friday" of the govt, and is the nodal agency meant for disseminating information on govt policies, programmes and their achievements. The Bureau works through its network of 38 regional branches and offers handouts to print, audio, visual and electronic media. It is the only interface between the media and the govt.

The PIB can, when the occasion arises, launch a blitzkrieg, multimedia publicity campaign to make or mar the future of a developmental programme. Projects rehabilitation, world Bank assistance amd environment oriented are its forte. PIB can issue handouts and recieve feedback. Handout could be in a a variety of formats including photo features, Facts at a Glance, Fact Sheets, illustrated features, Do you Know and glossaries.

Can the PIB stand against giant corporations bent on cutting forests, paving wetlands or filling up the sky with hydrocarbons particularly when those involved are closely connected with the Government?

5. Publications Division

Set up in 1941, the Publication Division, is a branch of the Bureau of Public Information. It is a publishing organisation of the govt. During the last 46 years, the Division has assumed

quite a status in the field of printing and distribution books and journals on matters of national importance. Its major aim is educating people and providing them educational literature at an affordable price. The books produced are on a variety of topics. Modern India, Indian History, Indian Art, National Heritage, Freedom movement in Hindi, English and Regional languages.

Of real importance to the public is its journal 'Yojana' that seek to carry the message of planning and economic development. The journal is brought out in 13 languages. It also brings out two special issues every year, one on Independence day and one on Republic day, education (both distance and tribal), reforms and on rural development. Yojana is a really informative magazine that can involve itself in really striking a balanced approach between environmental degradation and development. Its contributors are well known personalities, and the articles published are always of contemporary interest. Kurukshetra, a journal in English focuses on developments in agriculture and environment.

Bal Bharath in Hindi is meant for children. However, it has vast scope for bringing within its ambit children of varied interests and can turn this interest towards environmental issues and biodiversity. Since children can learn more easily than adults, the exposure to diverse problems of nature could start at an early age itself. Employment News, a weekly, a unit of publication Division, apart from providing information of vacancies for job seekers, provided in-depth specially written articles on current issues including international events. Test your knowledge, World this Week, India this Week can effectively focus on India's heritage and curent environmental problems plaguing the country.

6. Directorate of Field Publicity (DFP)

DFP is a field-oriented organisation that can play an important role in the task of educating people of our heritage and current issues, with the active involvement of people, to bring about an awareness and a change in their preconceived notions, if possible. The Department is equipped with men and material which are virtually taken to doorsteps of people. The audience is exposed to diverse socio-economic issues and cultural milieu of the country and inspire them to move ahead unitedly. The Dept. uses a variety of techniques including films, live performances, songs, dance and drama, oral communication, group discussions, seminars, symposia, and competitions of various kinds. Since each field unit is equipped with a mobile video projection system (MVPS), it provides a multifaceted self-contained publicity system.

Here is one department of the Government, which can really reach a very wide audience and create an indelible impact using both audio and visual media. Since mobility is a factor

to reckon with, reaching every nook and corner is an advantage that few other departments have. However, a dynamic leader for each group is required who is involved in the issue under discussion and one who can really motivate and educate people.

7. Directorate of Advertising and Visual Publicity

DAVP owes its allegiance to policies of the government and is meant for giving information about government's policies and programmes. Its other task is to motivate people to participate in country's developmental process. DAVP, it is alleged, is a true govt dept, has been used or misused by the government in power to "spread" information that has often been considered to mislead a citizen into believing that the government in power has 'great' achievements to its credit. DAVP also has been used for advertisements for the ruling party for its election campaigns.

DAVP puts up exhibitions, publish booklets, folders, posters and put up hoardings and can launch a multimedia campaign. DAVP has a regional office at Bangalore with about 35 field exhibitions units to coordinate its activities.

8. National Information Centre

NIC is a premier organisation in the field of information technology. It provides state of the art solution to information management and decision support. It has set up a satellite-based nationwide computer communication network (NICNET) that work on more than 650 nodes connecting the National Capital, 32 State Capitals and 500 district headquarters.

The NIC since its inception has been attempting to bring information to the people. It has been successful in doing this because of its judicious use of technology and its indigenous efforts of adapting frontline technologies to suit Indian conditions.

NIC has developed a large number of management information systems (MIS) for different aspects of agriculture, like national watershed development, seed management and integrated pest management systems and animal disease surveillance.

NIC can create a comprehensive computer database of Indian biodiversity and can provide MIS to monitor the ongoing work on projects to institutions involoved in it.

Conclusion

Most of the people, thanks to media, have heard of global warming, ozone depletion, deforestation and desertification. But most are unaware of how these forces and many more

can combine to put the entire planet in peril. For the first time an awareness is being created about the magnitude of the challenge that humanity faces and how hunanity's relentless push into natural habitats could spell doom for the magnificent biodiversity.

In order to master our problems, it is not enough if just an awareness is created. We need a realistic expectation of surmounting them, and a viable strategy to do so. Going backwards to achieve a balance with the natural world is hardly a viable solution. But at the present juncture of a new millenium, what is required is a less polluting, less resource-intensive technology so that the society can stand the test of time, and our great heritage is preserved. The new era calls for, what environmental writer Alan During describes as "cultural permanence"- meeting the needs of the present generation without geopardizing the prospects of the next. Or as the Harvard biologist Stephen Jay Gould puts it "We cannot win the battle to save species and environments without forging an emotional bond between ourselves and nature."

Biodiversity Of Coastal Karnataka : A Concept For Sustainable Utilisation Of The Resources And Their Conservation

S. A. Hussain
Biodiversity Initiative Trust, Mangalore.

Background

Resource values

The tropical estuarine/marine ecosystems are very rich in biological diversity which is suitably adapted to a wide range of habitats varying from mangrove swamps, lagoons, estuaries, tidal mudflats, sandy/rocky coasts, coral reefs, offshore islands to deep sea.

Coastal wetlands provide an enormous range of goods and services: directly and indirectly, such as food plants and food chain and breeding grounds for coastal and offshore fisheries. Wetland soils are alternately wetted and dried, which increases the release of nutrients and enhances the turnover of the organic matter. The movement of water during tidal cycles provides a steady supply of nutrients to various organisms dependent on wetland plants. Thus a healthy coastal wetland can support other plants and animals through food chains both within the estuaries and beyond its boundary in the high seas.

Coastal wetlands are highly productive spawning and feeding areas for a large number of fish species. Apart from providing a food base they also provide young fish protection form oceanic currents, strong sunlight and predators. They also encourage settling out of particles of organic matter nutrients which may have originated in the open sea. Shrimp species spawn at sea and then migrate to the coastal wetland nurseries where, together with the larvae of crabs and many species of fish, they grow quickly in the food rich habitat.

Mangroves support a wealth of fish, shellfish, prawns oysters, clams and mussels. The mudskippers inhabiting this zone feed on crabs and snails which in turn feed on decaying mangrove leaves and other vegetation. Snails range from the soil and sediment to roots and trunk where they feed on algae. Worms and microscopic plants and invertebrates, which are in super abundance in the estuaries, provide the necessary food chain for a large number of commercially important fishes.

Marine fish frequently move hundreds of kilometers up major rivers. The movements of species is linked to the water cycles of the coastal system.

The tropical marine ecosystem which includes its supporting system of coastal wetlands, rich in biodiversity, is a critical life support systems that provides fishery and plant products, water supply, flood control, erosion buffering, plant gene pools, wildlife habitat, recreation and tourism areas, as well as many other direct and indirect benefits.

Current status

The combined vast natural assets of both sea and estuaries, potentially worth crores of rupees every year in sustainable output, have been significantly eroded by over-exploitation and ill-conceived projects. This has led to serious loss of wetland biodiversity and the natural resource base of the economies in the region, particularly affecting rural poor.

Threatened species: The latest *Red Data Book* of IUCN - The World Conservation Union - lists several threatened species of Mammals, birds, reptiles and amphibians which are dependent on wetlands in Asia. Unfortunately, information available on fishes, invertebrates and wetland plants is too inadequate to permit even a preliminary estimate of the numbers of the threatened species of these groups.

Fisheries: All over Asia, fishing is an important activity as it provides a significant proportion of the protein intake of local people. Until recently this has been compatible with the preservation of biodiversity and integrity of the ecosystems. In recent years, however, traditional fishing methods have been replaced with modern commercial fishing techniques, this has often led to severe over-exploitation. Habitat degradation, pollution and eutrophication have further contributed to the depletion of commercial fish stocks and the virtual collapse of coastal fishery in some areas.

Aquaculture: In contrast to what many decision-makers believe, fish farming and shrimp farming is not a panacea for economic development of coastal lagoon and mangrove systems. The large-scale conversion of mangroves into shrimp ponds has been particularly damaging to many coastal ecosystems. Not all coastal lagoons and mangroves are by any means favourable for intensive aquaculture: many are best used as extensive farming - that is, traditional fisheries.

Mangroves : Despite their many values, mangrove ecosystems are amongst the most

severely threatened zones in India. The most serious threats are, over-exploitation for timber and firewood, timber and charcoal, reclamation for agriculture, industry and human settlement, conversion to aquaculture ponds, pollution form industrial and domestic effluent as well as pesticides runoff of agriculture.

COASTAL KARNATAKA

The state of Karnataka has a 270 km long coastline falling within its revenue districts of Udipi, Uttara and Dakshina Kannada and a total Exclusive Economic Zone (EEZ) of 8700 km^2.

The area receives an average 4000 mm of rainfall during the months of June-September. The precipitation has a short run-off through a network of large and small rivers that drain into the Arabian sea.

The entire area comprising of EEZ, shoreline vegetation and backwaters is very rich in biological diversity. A well watered but short hinterland beginning from the top of the Western Ghat complex provides all the ingredients to support the downstream coastal ecosystem.

Twelve major west flowing rivers systems, originating in the Tropical wet-evergreen forests of Western Ghats, meander through lowland forests, secondary woodlands and gently undulating plains and spread out into wide estuaries, lagoons and backwaters, extensive mudflats and several small patches of mangrove forests. These have resulted in a series of small estuarine systems along the long coastline. Most of these estuaries and creeks are narrow and permanently open to sea.

There are 11 main estuarine systems spread out in Coastal Karnataka. These are:

1. Uttara Kannada:

a. The estuary of Kalinadi river

b. The estuary of Gangavali river

c. The estuary of Aghanasini river

d. The combined estuaries of Sharavati and Dhareshwar rivers

2. Udipi district

e. The combined estuaries of Baindur and Sirur rivers

f. The combined estuaries of Kollur, Chakra nadi and Haladi at Gangolly

g. The combined estuaries of Swarna, Sita and Kodi rivers

h. The combined estuaries of Udyavar and Pangala rivers

3. Dakshina Kannada

i. The combined estuaries of Mulki and Pavanje rivers

k. The combined estuaries of Nethravati and Gurpur rivers.

Biodiversity

The area has a variety of fauna and flora in habitats ranging from tropical montane forests of Western Ghats to coastal mangroves. The region is well represented by land mammals, birds reptiles and other vertebrates and invertebrates. Both the shoreline and offshore areas have their own variety of rich biodiversity. Lists of some of the important species occurring in the coastal area along with a list of threatened species, have been included in the tables (see below).

Strategy for action

The threat to marine/estuarine systems in India in general, and Karnataka in particular, is so severe that urgent action is needed at all levels to contain this trend. Establishment of an Coastal Biosphere Command Area(CBCA) in Coastal Karnataka will be most appropriate under the prevailing conditions.

ESTABLISHING A BIOSPHERE COMMAND AREA IN COASTAL KARNATAKA

Rationale

Rapid industrialisation, steady growth of human population and the resultant demand for food & shelter and the changes in land use patterns have placed considerable stress on natural resources and ecosystem of the area. Hitherto pristine coastal zone along the Udipi, Uttara and Dakshina Kannada districts will be subjected to rapid developmental activities due to increase accessibility from the national Highway and the Konkan Railway. The next decade will find the area under constant influence of developmental activities, and some of the critical and fragile coastal systems will be under heavy pressure.

Management and protection of threatened species and critical habitats in a region which is under multi-sectoral and multi-dimensional influences is a difficult task. Unlike in the homogenous sites such as Forests, where it is easier to manage the system through establishment of Sanctuaries, Reserves and National Parks under a legal framework and

under a single authority, handling of the complex Coastal zone where human settlements, multi-agency operations in industry, agriculture and economic exploitation is being carried out from historical times, needs a different approach. Historical, socio-economic and commercial considerations will have to be accommodated along with the need for conservation of habitats, species and vital resources.

It will be possible to address the problems and at the same time institute adequate and proper conservation efforts through the establishment of Coastal Biosphere Command Area. The principles and objectives of Biosphere Reserve management could be adapted, modified and evolved from the following accepted criteria and designing making it to suit the local area needs.

Concept of Biosphere Reserve:

4.1 General principle

Biosphere Reserves are to be considered as forming an extensive network of natural laboratories. The emphasis will be on holistic treatment of environmental protection and resource conservation along with meeting the basic needs of the people inhabiting the area.

ACTION PLAN

The Action Plan is based on initial survey, protection, restoration, research and educational awareness.

Phase - I 6 - 8 months.

1. Survey:

- An initial rapid survey to be carried in the area to assess the ecological, socio-economic, demographic, land use/ownership, legal and political aspects.
- Preparation of a detailed Project Proposal based on above survey along with budgetary requirements.
- Identification of critical ecological sites for protection and restoration.
- Identification of Government departments other agencies, institutions and individuals operating in the area and who may be inducted into an integrated management/advisory committee/authority for the proposed CBCA.

AN INITIAL GRANT OF RS 5 LAKHS WILL HAVE TO BE PROVIDED TO START THE PROCESS. A COMPREHENSIVE AND DETAILED PROJECT PLAN SHOULD BE PREPARED FOR FURTHER FUNDING ON SHORT-TERM/LONG-TERM BASIS. An ad hoc Task Force will be constituted with a Chairman and membership consisting of local officials, experts and consultants.

Phase - II. Short-term and Long-term

A detailed plan will be prepared under Phase - I, which will include the following objectives:

Objective - 1.

Management

To set up a management strategy along with the necessary infrastructure and man-power to deal with the multipurpose objectives of the CBCA.
The guiding principle will be to encourage uses and activities that do not adversely affect the conservation and research functions. Guidelines will be instituted for sustained yields as well as increased productivity from the area without adversely affecting the ecosystem and without denying the aspirations and expectations for livelihood of the people at the same time.

Objective - 2.

In-situ conservation

Establishing infrastructure and materials for conservation of endangered and threatened species occurring in the area.

Actions:

- **Species recovery plans**
- **Species re-introductions**
- **Restoration of breeding and spawning grounds**
- **Establishing gene pools of local species.**

Objective - 3

Promoting and coordinating cooperative research relevant projects in conservation

biology in collaboration with local scientists, colleges, universities, experts and conservation NGO's.

Actions:

- **Mangrove ecology**
- **Ecology of benthic fauna & flora**
- **Ecology of endangered & threatened wildlife**
- **Socio-economics of local communities**

Objective - 4.

Developing monitoring activities to assess the trends and practices of development schemes and their impact on critical habitats and species and provide basis for scientific research and Environmental Impact Assessment(EIA) of present and future developmental projects in the area.

Actions:

- **EIA's of all developmental schemes**
- **Setting up regular sample plots for monitoring & research**
- **Collaborative studies with local, regional, national and international conservation organisations.**

Objective - 5.

Developing a strong coordinating links with local and regional government agencies such as, Revenue, Forest, Fisheries, PWD, Highways, Agri-horticulture, Animal Husbandry, Education, Law & Order, Coast Guard, Political agencies, Gram Panchayats, Zilla Panchayats Tourism and Transport & Shipping

Actions:

- **Establishment of a Coordinating Body**
- **Establishing a technical/scientific Advisory Body.**

Objective - 6

Promoting participation by local communities, fishermen, farmers and others in management and protection of the CBCA.

Actions:

- **Setting up of village committees and review groups**
- **Promoting social forestry for arresting soil and coastal erosion**
- **Educating local communities for cooperative traditional resource harvesting methods.**
- **Providing information, material and expert advice on eco-friendly and sustainable agriculture & fishery.**

Objective - 7

Promote environmental awareness among general public, decision makers, tourists, school and college students and local communities.

Actions:

- **Setting up of visitor centers at strategic places, with audio-visual aids, museums, recreational areas, trails, nature walks/boating etc.**
- **Setting up nature camps, training workshops.**

The following Tables tentatively list out species of fauna and flora occurring in and around coastal Karnataka. Large marine mammals such as whales have not been listed though they have been recorded in the coastal areas occasionally and accidentally. The list is by no means exhaustive. There may be many more species occurring here, some of them even threatened or even locally endangered. The lists will be updated eventually.

Table-1 : Estuarine vegetation

Species	Type	Zone
Avicennia officinalis	Mangrove	Coastal saline
A. marina	Mangrove	Coastal saline
Kandelia kandel	Mangrove	Coastal saline
Rhizophora mucronata	Mangrove	Coastal saline
Sonneratia alba	Mangrove	Coastal saline
Aegiceras corniculatum	Mangrove	Upstream mesohaline
Excoecaria agallocha	Mangrove	Upstream mesohaline
Rhizophora conjugata	Mangrove	Upstream mesohaline
Sonneratia caseolaris	Mangrove	Upstream mesohaline
Salvadora persica	Shrub	Upstraem mesohaline
Clerodendrum inerme	Shrub	Upstream mesohaline
Acanthus ilicifolius	Shrub	Upstream mesohaline
Enteromorpha intestinalis	Alga	Backwaters
Chaetomorpha lineum	Alga	Backwaters
Gracilaia verrucosa	Alga	Backwaters
Ipomoea perscaprae	Shrub	Coastal sand dune
Asparagus dumosus	Shrub	Coastal sand dune
Spinifex littoreus	Shrub	Coastal sand dune
Cyperus aristatus	Shrub	Coastal sand dune
Thespesia populnea	Tree	Coastal sand dune
Casuarina equisetifolia	Tree	Coastal sand dune
Vitex negundo	Shrub	Backshore
Pandanus Sp.	Shrub	Backshore
Durana repens	Shrub	Backshore
Anacardium occidentale	Tree	Backshore
Cocos nucifera	Tree	Backshore

Table-2 : Birds - Mainly pelagic but occasionally visiting coast.

Species	Pelagic	Status
Wedgetailed Shearwater *Procellaria pacifica*	✓	Summer visitor
Audubon's Shearwater *Procellaria i. persica*	✓	Breeds in Maldives
Wilson's storm petrel *Oceanites oceanicus*	✓	Summer visitor
Redbilled Tropic bird *Pheaton aethereus*	✓	Summer visitor
Longtailed Tropic bird *P. lepturus*	✓	Breeds in Maldives
Masked Booby *Sula dactylatra*	✓	Monsoon visitor
Brown Booby *S. leucogaster*	✓	Monsoon visitor
Least Fregate bird *Fregata ariel*	✓	Breeds in Maldives

Table-3 : Birds - Visiting/breeding in estuaries - 135+ spp.

Group & No. of Species	Status	Habitat
Cormorants - 3 spp.	R/LM	Tidal lagoons
Herons/Egrets - 12 spp.	R/LM	Estuaries/lagoons
Storks - 6 spp.	R/LM	Estuaries/lagoons
Ducks - 8 spp.	M	Inland marshes
Eagles/Kites etc – 7 spp.	R/LM/M	Lagoons/marshes
Rails/Coots - 10 spp.	R/LM	Marshes/backwater
Jacana/Crabplovers/ Stilts/Pratincoles etc-10 spp	R/LM/M	Estuaries/Lagoons/Backwaters.
Plovers - 10 spp	M	Coastal mudflats
Sandpipers/Curlews- 30spp	M	Coastal mudflats
Gulls/Terns - 19 spp.	B/LM/M	Estuaries/Lagoons
Kingfishers & Passerines - 20+ spp.	B/LM	All along the Coast

R = Resident; LM = Locally migrant; M = Migrant; B = Breeding

Table-4 : Reptiles - Turtles/sea snakes

Species	Marine	Estuarine	Status
Loggerhead Turtle *Caretta caretta*	✓		?
Green Turtle *Chelonia mydas*	✓		?
Hawksbill Turtle *Eretmochelys imbricata*	✓		?
Leatherback *Dermochelys coriacea*	✓		?
Olive Ridley *Lepidochelys olivacea*	✓		?
Hook-nosed sea snake *Enhydrina sohistosa*	✓	✓	?
Sea snake sp. *Laticauda colubrina*	✓	✓	?
Sea snake sp. *Hydrophis* Sp.	✓	✓	?

Table-5 : Marine mammals - Dolphins/Porpoises

Species	Marine	Estuarine	Status
Spinner dolphin *Stenella longirostris*	✓	✓	?
Bottlenose dolphin *Tursiops truncatus*	✓	✓	?
Black dolphin *Sousa chinensis*	✓	✓	?
Humpback dolphin/s *S. plumbea & S. aduncus*	✓	✓	?
Plumbeous dolphin *Sotalia plumbea*	✓		?
Indian Porpoise *Neomeris phocaenoides*		✓	?
Common dolphin *Delphinus delphis*	✓	✓	?

Table-6 : Land Mammals

Species	Habitat	Status
Malabar Fishing cat *Felis viverrina*	Mangroves, tidal marshes, backwaters	Rare
Smooth Indian Otter *Luthra perspicillata*	Creeks, estuaries, open sea	Uncommon

Table-7 : Marine vertebrates - Sharks/Rays

Species	No. of spp.	Habitat
Sharks	60+	Deep sea/estuary
Skates	10	Muddy sea floor
Rays	18	Muddy sea floor

Table-8 : Marine - Fish & Crustaceans of commercial value

Name	No.s	Habitat	Breeding area
Fin fish	200+	Deep sea, lagoons	Estuaries
Prawns	80+	Deep sea, lagoons	Estuaries
Lobsters	6+	Deep sea, lagoons	Estuaries
Crabs	8+	Lagoons, sea shore	Estuaries/mudflats

Table-9 : Marine & Estuarine invertebrates of commercial value

Species	No. of spp.	Habitat
Gastropods - Chanks/Turbos	15+	Estuaries/mudflats/offshore
Bivalves - Oysters/mussels	20+	Estuaries/offshore
Holothurians - Sea cucumbers	12+	Inshore
Cephalopods - Cuttlefish/squids	8+	Estuaries

Table-10 : Rare & Endangered fauna & flora

Species	Type	Zone	Status
Periophthalmus Sp.	Mud Skipper	Inter-tidal	Uncommon
Fishing cat	Mammal	Backwaters	Rare*
Otter	Mammal	Backwaters	Rare*
Osprey *Pandion haliaeetus*	Raptor	Backwaters	Endangered*
Green Turtle	Reptile	Sea	Rare*
Olive Ridley	Reptile	Sea	Rare*
Water Monitor *Varanus salvator*	Reptile	Backwaters	Threatened*
Common monitor *V.benghalensis*	Reptile	Backwaters	Threatened*
Estuarine Crocodile *Crocodilus porosus*	Reptile	Backwaters	V. rare*
Cryptocoryne cognatoides	Marsh plant	Coast	Rare**
Hubbardia heptaneuron	Grass	Tidal Rivers	Extinct(?)**
Nelumbo nucifera	Plant	Ponds	Over-exploited
Hydrobryopsis sessilis	Plant	Coastal streams	Rare
Aponogeton appendiculatus	Plant	Coast	Threatened

* Included in Schedule I of the Wildlife Protection(1972) Act.

** Included in IUCN Red Data Book of Rare & Endangered Plants.

ABSTRACTS RECEIVED

Of the six Abstracts received, two papers were presented at the Conference, but unfortunately full papers were not received.

To give a comprehensive picture of the area as biodiversity - rich and its potential for future research and conservation, we have included the abstracts here. - Eds.

Caecilian Diversity of Western Ghats

Dr. G. K. Bhat

Department of Zoology, Sri J. C. B. M. College, Sringeri - 577 139

Caecilians are limbless amphibians of great ecological and taxonomical significance. However, owing to their secretive burrowing mode of life and difficulty in procuring them, these animals are least studied and considered while describing amphibian biology. India, one of the megadiversity countries, is richest in caecilian diversity also. Out of 16 species reported from India, 14 species, all endemic, occur in Western Ghats, one of the worlds 18 biodiversity hotspots.

Caecilians have snake like body with rings or annuli on it. They possess small eyes, sometimes covered with skin, a pair of nostrils at the tip of snout and a pair of tentacles of either side of the head. The mouth has teeth in both upper and lower jaws. The tongue is fused with the floor of the buccal cavity and it cannot be protrued out. Earthworms and termites constitute their main diet. There is no sexual dimorphism.

The field studies and literature review indicate that 10-12^0 N latitude as the richest zone of caecilian diversity. Caecilians generally inhabit loose moist soil rich in humus at different altitudes wih an average temperature of 24.5 + 1^0 C. Interestingly caecilians unlike frog species are not suceptible to extinction with forest depletion as they are quite common in orchards such as arecanut or coconut which have perennial water supply, but without heavy chemical input. This suggests that some kind of human interventions or landuses may be compatible with conservation of certain elements of biodiversity. The complete clustering of species on the basis of soil parameters showed their commonly shared narrow microhabitat preferences i. e. considerable niche overlap.

The rearing of caecilians provided unique data on their general activity, foraging behaviour and metabolism. Further it not only enabled studies on their breeding behaviour, but also possibility of *ex situ* conservation.

Fire Impact Assessment in Western Ghat Forest

Dr. M. H. Swaminath
Director and Conservator of Forests, Forest Research and Training Institute (FoRTI),
Karnataka Forest Department, Bangalore.
and
Arun Kumar A. N.
Senior Technician, Forest Research and Training Institute (FoRTI),
Karnataka Forest Department, Bangalore.

Western Ghat forests are one of the 12 mega biodiversity spots of the world. Their structure and functions have been influenced by the human interference since many centuries. The semi evergreen and deciduous forests are very vunerablr to fire impact during summer months. As a result the species composition of the forest in the fire prone areas. The findings of the study indicates tremendous change in the forest composition due to repeated fire among different forest types.

Components of the Reptilian Diversity of the Western Ghats Environs.

B. K. Sharath
Department of Zoology, Vivekananda College,
Nehru Nagar P. O., Puttur (D. K.) - 574 203

The Western Ghats with its rich biodiversity supports a wide variety of reptiles too. Reptiles being one of the most diverse taxa itself contributes immensely to the character diversity or the gene diversity of the area. As far as reptiles are concerned, the habittats of the Western Ghats can be divided in to three major regions. The West coastal plains, the western slopes and the mountain highlands. Among the unique reptiles found in large numbers, but now dwindling, are the Crocodiles and Pythons. In the slopes the king cobra; the Travancore tortoise; the cane turtle; the Monitor lizard; the dwarf lizard and the pit viper are those facing the threat of extinction. In the upland there is very little information regarding the occurrence of the different taxa. However, the family Uropeltidae is one whole family endemic to the Western Ghats and forests of Srilanks. Although around 33 species of Uropeltids are reported from Western Ghats, most of the work is restricted to the South of the Palghat gap. In my paper I have surveyed the reptiles that have been reported from the Western Ghats and have compared it to the one's found in the Western Ghats of Karnataka.

Overview of Coconut Plantations in Western Ghats Environs and Sustainable Resource Utilization

K. U. K. Naopoothiri
Director, Central Plantation Crops Research Institute, Kasaragod - 671 124
and
E. V. V. Bhaskara Rao
Director, National Research Centre for Cashew, Puttur - 574 202, D. K.

Coconut is cultivated in the coastal Western Ghats since centuries. It is naturalised in the coastal areas and also grown as commercial venture in the homesteads, small and marginal holdings. In the recent years large plantations are also coming up. Karnataks with a total area of 259,000 ha. accounts for 15.6 per cent of coconut area in the country, with the production of 13 million nuts ranks third in the country. Coconut plantations are best known for conserving biodiversity of forest plant species in the gardens. Researches conducted in cropping systems by Central Plantation Crops Research Institute are well adopted in these areas and provide sustainable income to the coconut farmers. Coconut also has tremendous potential for conserving the soil fertility and resources through recycling of large amounts of coconut fronts, spades, etc. The mixed copping systems developed also permits growing of milch animals. Intercropping, multistoried cropping and mixed cropping models make the coconut cultivation a sustainable proposition with high remunerative value. The contributions made in the development of coconut varieties, integrated plant nutrient management practices and plant protection protocols are discussed.

Overview of Coffee Plantations in Western Ghats Area

R. P. Ananda Alwar, Agricultural Chemist
and
R. Naidu, Diector of Research
Central Coffee Research Station - 577 117
Chikmagalur district.

Coffee is a popular beverage of mankind that cheers the millions the world over. In India, traditionally Arabica and Robusta are the two important commercial species of coffee cultivated in the hills and valleys of Western and Eastern Ghats over an area of 3.00 lakh ha. of which 50% land is shared by these two. The average production is around 200,000 MT per annum and sixty percent of the produce is exported contributing nearly 1500 crores of

rupees to the state exchequre. The coffee industry provids an employment for 4 lakh people in cultivation, processing and trading sectors. Karnataka is the largest producer contributing 70% of the total production followed by Kerala and Tamil Nadu. Coffee is primarily grown as silvi - horticultural crop under shade tree cover for its optimal performance. Contribution towards the preservation of forest lands for sustainable use, the positive impact of shade on forest ecology and also the components detrimental to environment including coffee processing activities and the possible solutions to offset the problems are discussed in this paper.

Overview of Cashew Plantations in Western Ghats Environs

E. V. V. Bhaskara Rao
Director, National Research Centre for Cashew,
Puttur - 574 202, D. K.

In Karnataka the total area under cashew is estimated to be 85,000 ha with the production of 52,000 MTs of raw nuts during 1996-97. The average productivity is around 690 Kg per ha. Dakshina Kannada with 54,000 ha and Uttara Kannada 17,826 ha account for 85.5 per cent of the total area in the State with the production accounting for 34,000 MTs of raw nuts (90% of production in the State). The plantations raised prior to 1990 were of seeding origin and in most of the cases unknown origin seeds were raised in the plantations. One attractive feature for cashew cultivation in the coastal areas of Karnataka is the well estabilshed processing industry in Dakshina Kannada district. There are over 56 processing factories with the processing capacity of 28,000 MTs. The development of cashew in the coastal Karnataka is well supported by the Research Institutions, namely, National Research Centre for Cashew, Puttur (Karnataka) and University of Agricultural Sciences with its Research Stations at Ullal and Brrahmavar. The production package consisting varieties suitable for cultivation in Dakshina Kannada and Uttara Kannada, fertilizer recommendations and plant protection measures were evolved. The recent researches also indicated the profitability of taking up intercropping with fruit crops like pineapple and taking up high density plantings with cashew itself. Cashew cultivation per se had beneficial effecs in terms of soil conservation, especially in the hill slopes. The current status of the plantations and future strategies for production are presented in this paper.

BIODIVERSITY INITIATIVE TRUST (BIT)

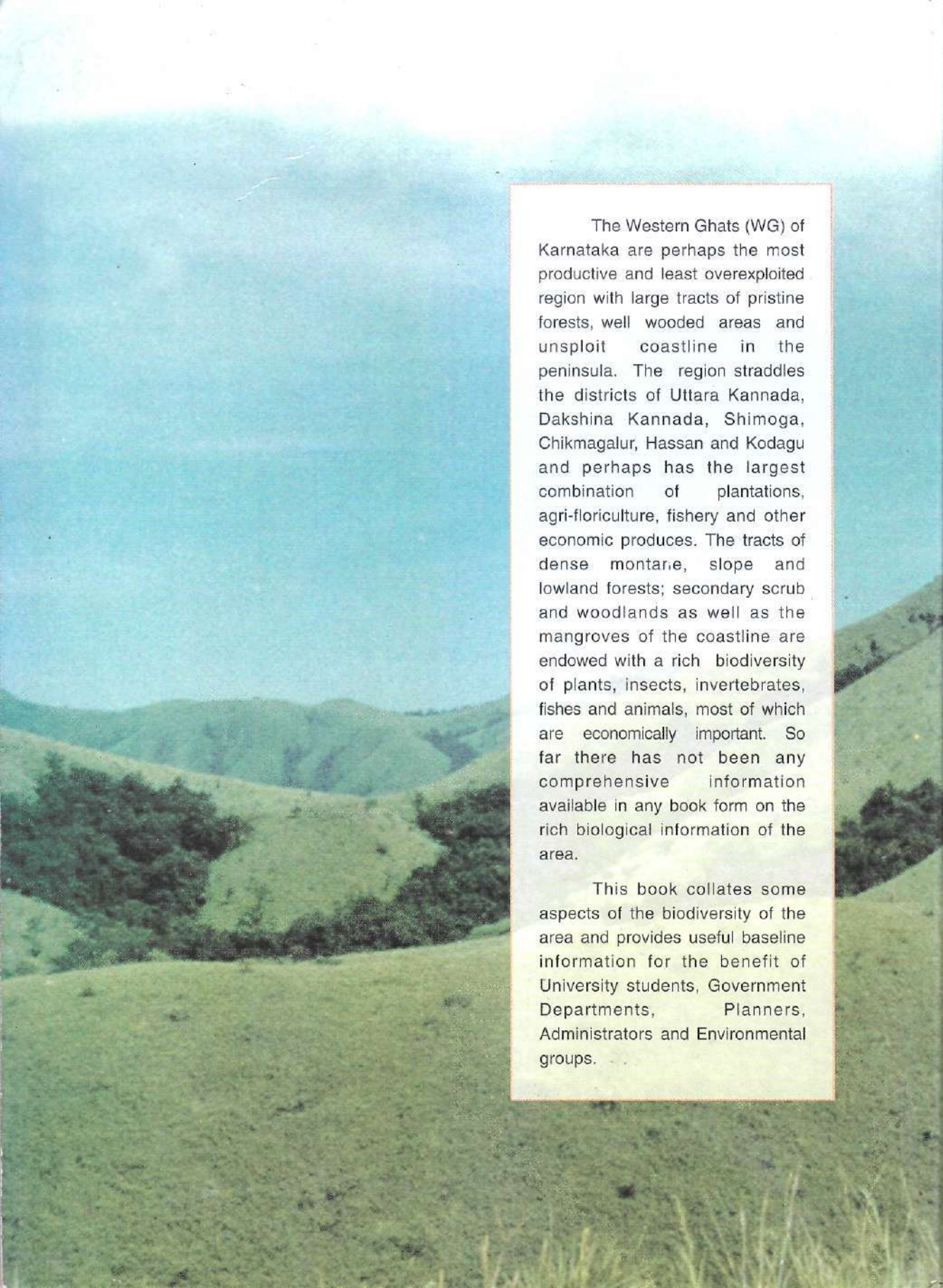
Biodiversity Initiative Trust strives to provide necessary services to the country in general and relevant institutions in particular in matters relating to sustainable utilisation and conservation of biodiversity in India. Its main objectives, among many, are:

a) identifying and setting biodiversity initiatives through collection, analysis, dissemination and use of information on biological resources of the region for the benefit of common people.

b) assisting and involving rural and urban communities, particularly women, in utilising the indigenous bioresources for their own benefit in a sustainable and equitable manner.

The Trust is governed by a band of dedicated Academicians, Research Scientists, Environmental Conservationists, Professionals, Agri-Horticulturists, Financial experts and able Administrators. There is a range of talent mixed with enthusiasm, dedication and a strong commitment to the cause.

For details contact : Biodiversity Initiative Trust ®,
"Basera", Amar Alva Road,
Monkey Stand,
Mangalore - 575 001.
Karnataka



The Western Ghats (WG) of Karnataka are perhaps the most productive and least overexploited region with large tracts of pristine forests, well wooded areas and unsploit coastline in the peninsula. The region straddles the districts of Uttara Kannada, Dakshina Kannada, Shimoga, Chikmagalur, Hassan and Kodagu and perhaps has the largest combination of plantations, agri-floriculture, fishery and other economic produces. The tracts of dense montane, slope and lowland forests; secondary scrub and woodlands as well as the mangroves of the coastline are endowed with a rich biodiversity of plants, insects, invertebrates, fishes and animals, most of which are economically important. So far there has not been any comprehensive information available in any book form on the rich biological information of the area.

This book collates some aspects of the biodiversity of the area and provides useful baseline information for the benefit of University students, Government Departments, Planners, Administrators and Environmental groups.